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THE GASKILL STEAM PUMPING ENGINES.

THE matter of obtaining increased water supply for cities, and the introduction of water in new places by artificial means, under pressure, for domestic use and the extinguishing of fires, are subjects which have deservedly received the most careful consideration from engineers, and are steadily being subjected to closer examination by the public. As pumping engines have been largely used for the purpose of affording such water supply, by either pumping into reservoirs, whence the water is distributed by pipes, or by pumping direct into the water mains, the demand on account of such use has led to a large degree of attention being paid to their improvement.

There has been, therefore, a keen competition among the manufacturers of pumping engines to produce machinery of comparatively low first cost, that will require a minimum of expense for care and maintenance, and that will give the largest amount of duty for the fuel consumed. In this line the Holly Manufacturing Company, of Lockport, N. Y., has been eminently successful. The company manufactures steam pumps of all sizes, and for every variety of service, but it has attained its wide reputation principally on account of the success it has achieved in furnishing pumping engines for the supply of water for cities and towns under the Holly system. According to the principle of this system, the machinery forces the water directly into the street mains, without the necessity of a standpipe or a reservoir, the amount of water to be furnished being susceptible of regulation automatically, according to what is drawn for daily or hourly use, up to the limit provided.

The pressure or head at which the water shall be furnished is likewise fixed at a certain average, but with provision for largely increasing it in cases of emergency, as for fires, when sufficient pressure can be put on the water in the mains to allow of the hose being directly attached, and streams thus thrown equal to those obtained by a steam fire engine. This perfect regulation of the pressure is attained by the use of the Holly hydrostatic automatic regulator, which relieves the engineer from almost constant attention at the throttle valve, and takes away all tendency to "water hammering," as often seen in other well known pumping engines, and entirely removes from the machinery, mains, and service

Record of the Performance of the Gaskill Pumping Engine, at Saratoga, N. Y. David L. Holland, Engineer.	Revolutions per Week.	Pounds of Coal per Week.	Water Pressure.	Steam Pressure.	Vacuum.	Gallons Pumped per Week.	Duty.
January 5, 1884	81,070	29,500	104·16	65	28·6	15,559,278	102,57 ,342
January 12, 1884	91,310	31,000	108·11	65	28·5	17,534,580	106,886,417
January 19, 1884	92,070	33,600	105·85	65	28·5	17,670,443	106,778,584
January 26, 1884	94,670	34,700	107·3	65	29	18,169,445	107,771,936
February 2, 1884	95,840	34,000	105·2	65	29	18,393,996	109,170,900
February 9, 1884	92,590	33,400	106·4	65	29	17,770,248	108,587,489
February 16, 1884	89,090	31,900	105·88	65	29	17,098,809	108,869,770
February 23, 1884	85,870	30,400	105·56	65	29	16,480,513	109,740,760
March 1, 1884	86,860	30,000	106·4	65	29	16,674,337	109,174,589
March 8, 1884	92,210	32,500	102·14	65	29	17,697,312	106,287,477
March 15, 1884	43,590	*14,900	102	65	29	8,174,048	107,885,884
March 22, 1884	63,090	†22,400	102·33	60	29	12,108,485	106,105,965
March 29, 1884	72,330	26,400	102	60	29	13,879,948	102,867,408
April 5, 1884	70,530	25,600	102	60	29·5	13,536,399	103,456,954
April 12, 1884	66,560	24,000	102	60	29	12,780,919	104,188,675
April 19, 1884	61,960	22,400	102·3	60	29	11,885,853	104,124,060
April 26, 1884	59,410	22,400	103·57	60	29	11,402,204	101,127,289
May 3, 1884	62,360	23,200	103·9	60	29	11,968,380	102,814,980
May 10, 1884	58,080	22,400	104·8	60	29	11,135,430	99,437,194
Average	79,758	28,838	104·05	62·8	28·9	15,307,558	105,816,459

* Run by water power 3½ days. † Run by water power 1½ days.

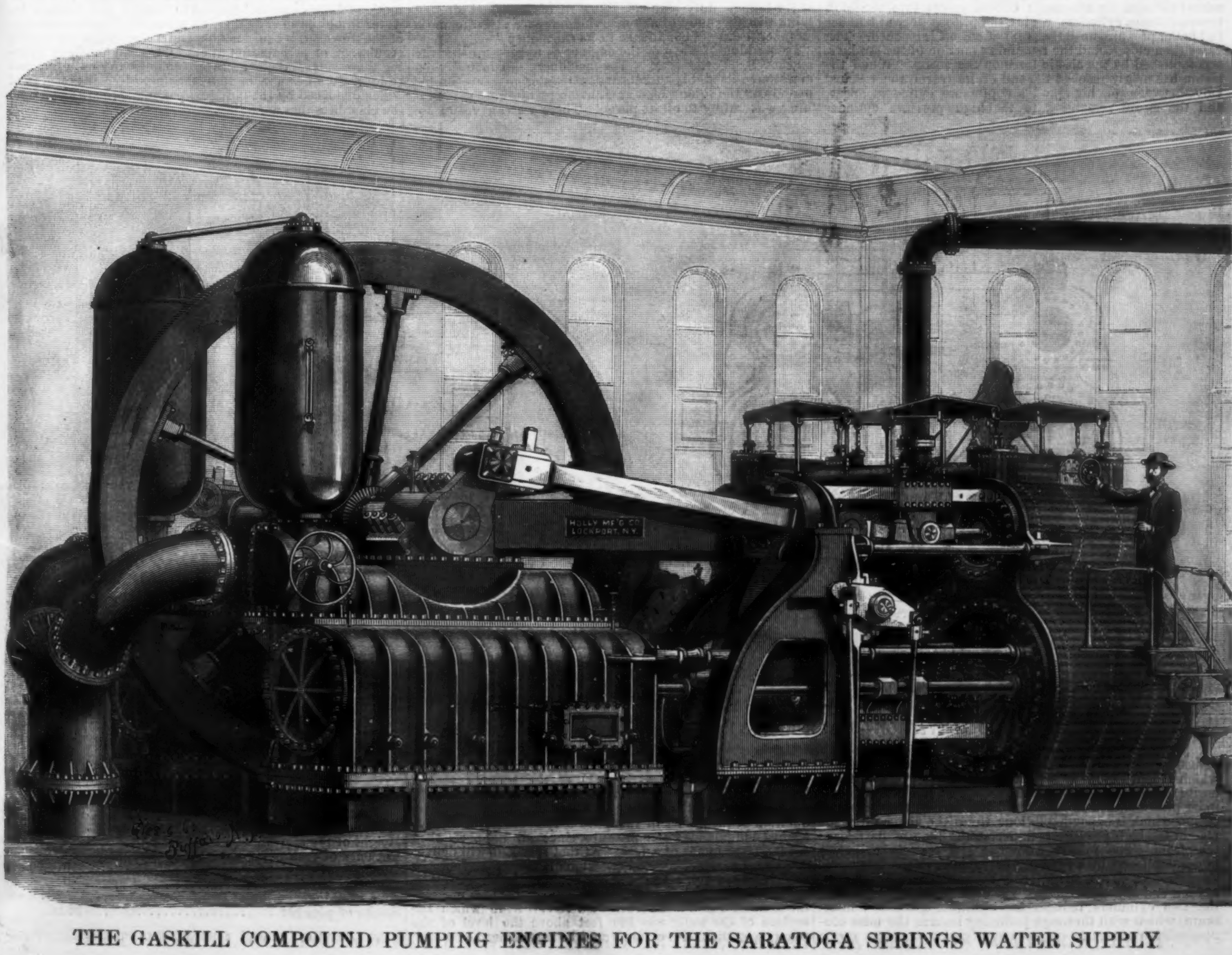
pipes the strains due to constantly changing pressures, while also effecting a great saving in fuel and in the wages for attendance.

Although the Holly system has now been prominently before the country for more than ten years, its steadily increasing adoption has been largely due to the great improvements this company has originated in pumping engines. Mr. Harvey F. Gaskill, the engineer and superintendent of the company's works, has made many of these improvements, and the Gaskill horizontal compound pumping engine, shown on this page, represents probably about as excellent a piece of work of this description as was ever built. It is a five million gallon engine—though the contract under which it was built called for only four million gallons of service per day—set up at Saratoga, N. Y., about a year ago, and has been steadily in operation ever since. Its regular performance during nineteen weeks of this year is given in the accompanying table, showing a very high degree of economy and efficiency regularly maintained.

The contract requirements of the engine were a pumping capacity of four million United States gallons in twenty-four hours, working at eighteen revolutions per minute against a pressure of eighty pounds per square inch, and a duty equal to 80,000,000 pounds of water raised. It is impossible for the mains ordinarily to carry all the water so provided for, but it will be seen that in both duty and pressure the average of the engines has been more than 30 per cent. above what was called for by the contract.

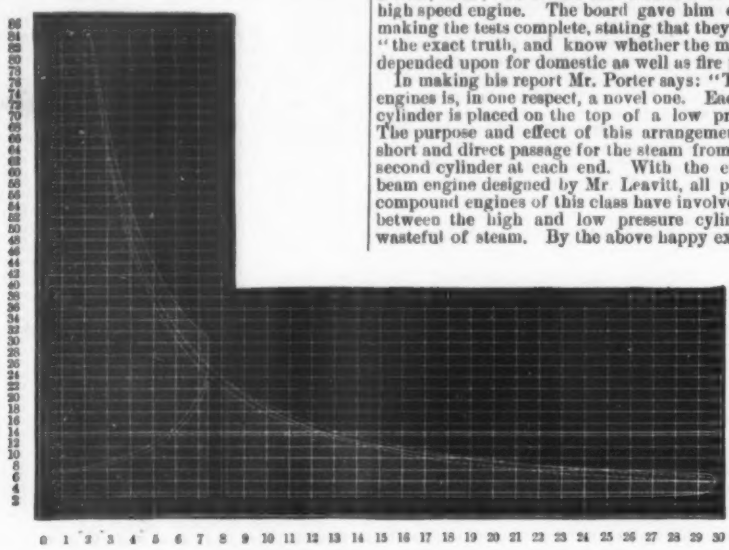
These pumping engines are thus described: On a pair of iron bed plates are mounted the two pumps, and in direct line therewith the two low pressure steam cylinders, with the piston rods of the low pressure steam cylinders connected to the pump piston rods. Between the pumps and steam cylinders are placed beam supports, which are firmly bolted to the bed plates, and also rigidly stayed by wrought iron struts to the pumps and steam cylinders. These beam supports carry the beam shafts and beams, the lower end of the latter being connected to the cross heads of the low pressure cylinders by means of links.

On the top of the pumps are placed the main shaft bearings, which support the shaft, fly wheel, and cranks, the latter being keyed to the shaft at right angles to each other. On top of the low pressure steam cylinders are mounted the



THE GASKILL COMPOUND PUMPING ENGINES FOR THE SARATOGA SPRINGS WATER SUPPLY

two high pressure steam cylinders, with their centers in the same horizontal plane as the center of the main crank shafts. The cross heads of the high pressure steam cylinders are connected by means of links to the upper ends of the beams, and the beams are in turn connected by means of connecting rods to the crank pins. From the high pressure steam cylinders heavy cast iron girders extend to the pillow blocks. On the inner end of each of the beam centers an arm is keyed, from which the air pumps are driven. The valves of the steam cylinders are operated by means of eccentrics on a shaft, which is driven from the main shaft through small bevel gears. The admission valves to the high pressure steam cylinders are of the double beat poppet pattern, so arranged as to open at the proper time and to close at any desired point of the stroke. The exhaust valves from the high pressure cylinder are also the admission valves to the low pressure steam cylinders, and are ordinary slide valves re-



maining open somewhat less than the time required to make a complete stroke. The exhaust valves from the low pressure cylinders are also plain slide valves, operating the same as the high pressure exhaust valves.

The pump plungers are arranged to work through glands in the center of the pumps, and are accessible from the covers at the end of the machine. The pump valves are placed on horizontal plates below and above the line of plunger travel. The glands above mentioned divide the valves of one end of the pump from those of the other end at the center of the valve plates.

The operation of the machine is as follows: Steam is admitted through the automatic cut-off valves into the high pressure steam cylinders, urging the pistons forward under full boiler pressure until the point of cut-off is reached. The valve then closes, and the remaining portion of the stroke is accomplished by the elastic force of the steam. When the piston has nearly reached the end of its travel, the exhaust valve between the high and low pressure cylinders opens, and the steam remaining in the high pressure cylinder

This engine is also built to operate as a non-compound engine, in which case the upper or high pressure steam cylinders and connections are omitted, and the lower steam cylinders are provided with automatic cut-off valves. Steam is admitted to these cylinders direct from the boiler, and exhausted into the condenser. This mode of construction is adapted to small places, and to cities and villages where the cheapness of fuel renders the first cost of the machine a matter more to be considered than the annual saving of fuel; although, even when constructed as a non-compound engine, a duty of 50,000,000 foot pounds of work can be obtained from 100 pounds of coal.

Exhaustive examinations of the working of these engines have been made by engineers of high repute. One of the most thorough tests ever made of such engines in this country was carried through in June, 1883, at the request of the Saratoga Board of Water Commissioners, by Mr. Charles T. Porter, M.E., and former manufacturer of the Porter-Allen high speed engine. The board gave him every facility for making the tests complete, stating that they wished to get at "the exact truth, and know whether the machine could be depended upon for domestic as well as fire purposes."

In making his report Mr. Porter says: "The design of the engines is, in one respect, a novel one. Each high pressure cylinder is placed on the top of a low pressure cylinder. The purpose and effect of this arrangement is, to obtain a short and direct passage for the steam from the first to the second cylinder at each end. With the exception of the beam engine designed by Mr Leavitt, all previous plans of compound engines of this class have involved long passages between the high and low pressure cylinders, which are wasteful of steam. By the above happy expedient, this objectionable feature is got rid of in these engines, and they are enabled to take rank among the most economical pumping engines. Special interest attaches to this trial, from the fact that these have been the first engines built after this design. In the details through which the general plan has been carried out, there are no features which seem open to criticism, but, on the contrary, all seem entitled to commendation. The construction is thoroughly mechanical in every respect. The forces are transmitted and the strains are resisted in the manner theoretically the most correct. The parts are strong and well proportioned, and the workmanship is excellent. The result is seen in the performance of the highest duty without any sign of labor. I do not think that the study of any machine has ever given to me a stronger feeling of confidence in its durability."

In speaking of a test of the engines as to pressure for fire service, Mr. Porter says: "The machinery satisfactorily demonstrated its ability to run under a water pressure of 140 pounds on the square inch at eighteen revolutions per minute 'with safety to all its parts.' There was an entire ab-

but Saratoga has the very same thing, with the capacity for delivering a volume far greater than can be carried away."

Saratoga is supplied with water for all purposes upon the direct service system, the water being pumped from a collecting reservoir, known as Loughberry Lake, directly into the distributing mains. After canvassing several doubtful methods of measuring the delivery of the pumps, for the purpose of an exact trial, without cutting off the force main (a proposition which could not be entertained by the Water Board), it was finally deemed sufficient to carefully measure the diameter and stroke of plungers, and from this data and the revolutions of engine during the trial, with such an allowance for slip or loss of action as was justified by precedent, to estimate the delivery of pumps. The displacement of two plungers, each twenty-one inches diameter and thirty-six inches stroke, with a single rod four inches diameter for each revolution of the engine, in United States standard gallons is 191·923. This quantity, reduced by a proper allowance for loss of action (with packing rings and valves tight under pressure), represents the approximate actual delivery of pumps.

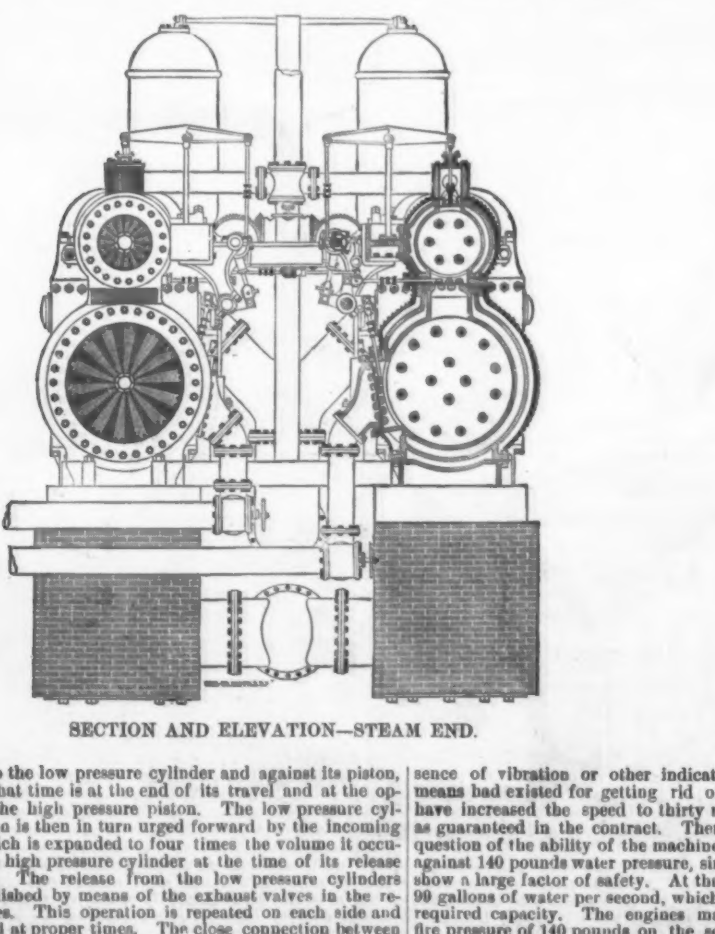
The pumps built by the Holly Company for the water supply of Memphis, Tenn., were substantially similar to the pumps of the Saratoga engine, and showed upon measurement by reservoir a delivery of 96·57 and 97·56 per cent. of the plunger displacement, so that this trial may be considered an entirely practical one for actual amount of water delivered in the mains.

The following are the principal dimensions of the engines:

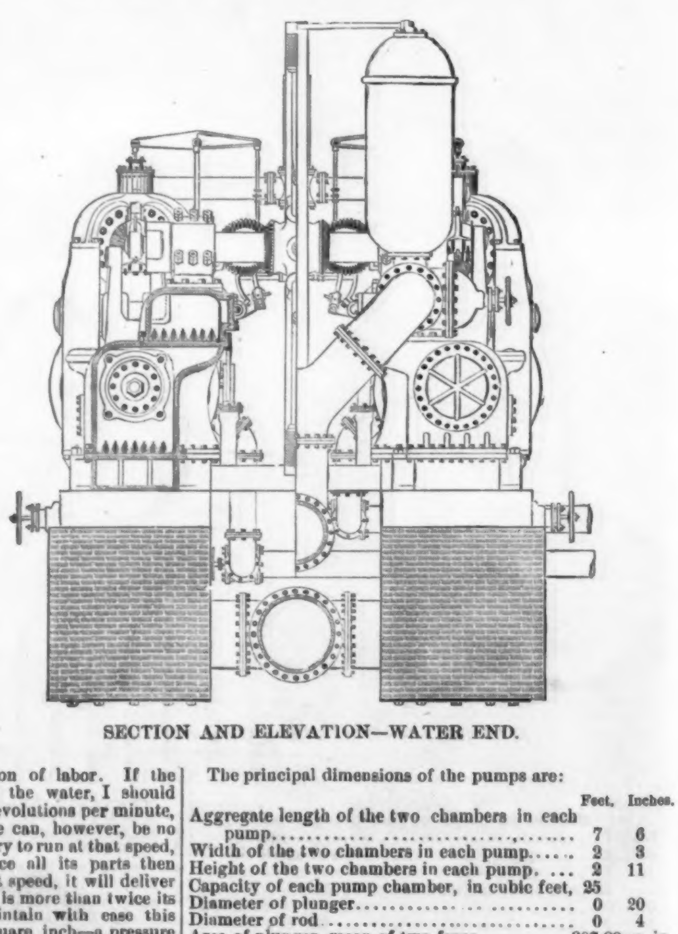
Stroke of all cylinders				36 in.
Diameter high	pressure	cylinders		21 "
"	"	"	piston rods	3 "
"	low	"	cylinders	42 "
"	"	"	piston rods	3·5 "
Clearance high		"	cylinder	2·35 p. ct.
"	low	"	"	2·50 "
Diameter of fly wheel				12·33 ft.
Weight "				12,000 lb.
Diameter of main shaft				10 in.

Mr. Porter's report is accompanied with several indicator diagrams, showing remarkable uniformity in the working of these engines. But they have worked even better since their regular official trials, and we give herewith a diagram more recently taken—a combined diagram—showing the expansion through the high and low pressure cylinders, each division on the vertical scale representing two pounds pressure of steam, and each division on the horizontal scale one cubic foot of steam.

The pumps are provided with by-pass pipes and valves, forming, when the latter are open, a communication between the two chambers of each pump. Their function is this: At the instant of starting, the engines are able to exert only a portion of their power, because no steam has yet been admitted to the low pressure cylinders. The pressure of water is liable to be greater than the steam in the high pressure cylinders alone can overcome. In such a case, the by-pass valves can be opened, when the water flows through them into the opposite chambers, the pressure on the opposite ends of the plungers is in a measure equalized, and the engine is enabled to start. As soon as it is fairly in motion, these valves are closed. They are available, also, when the motion of the engines required to supply the demand for water would be so slow that, on account of the insufficiency of the fly wheel, it could not be maintained with the desired regularity, or perhaps not at all. Then, by partially opening these valves, the engines are enabled to run faster, and so to maintain their motion satisfactorily, the excess of water displaced by the plungers passing through them into the chambers that are filling.



SECTION AND ELEVATION—STEAM END.



SECTION AND ELEVATION—WATER END.

rushes into the low pressure cylinder and against its piston, which at that time is at the end of its travel and at the opposite of the high pressure piston. The low pressure cylinder piston is then in turn urged forward by the incoming steam, which is expanded to four times the volume it occupied in the high pressure cylinder at the time of its release therefrom. The release from the low pressure cylinders is accomplished by means of the exhaust valves in the return strokes. This operation is repeated on each side and at each end at proper times. The close connection between the two cylinders reduces the clearance spaces to a minimum, which with thorough jacketing insures the most economical use of steam.

sence of vibration or other indication of labor. If the means had existed for getting rid of the water, I should have increased the speed to thirty revolutions per minute, as guaranteed in the contract. There can, however, be no question of the ability of the machinery to run at that speed, against 140 pounds water pressure, since all its parts then show a large factor of safety. At that speed, it will deliver 99 gallons of water per second, which is more than twice its required capacity. The engines maintain with ease this fire pressure of 140 pounds on the square inch—a pressure the same as would be afforded by a reservoir in which the surface of the water was 320 feet above the level of the pumping station. Now this would be a great head of water;

The principal dimensions of the pumps are:

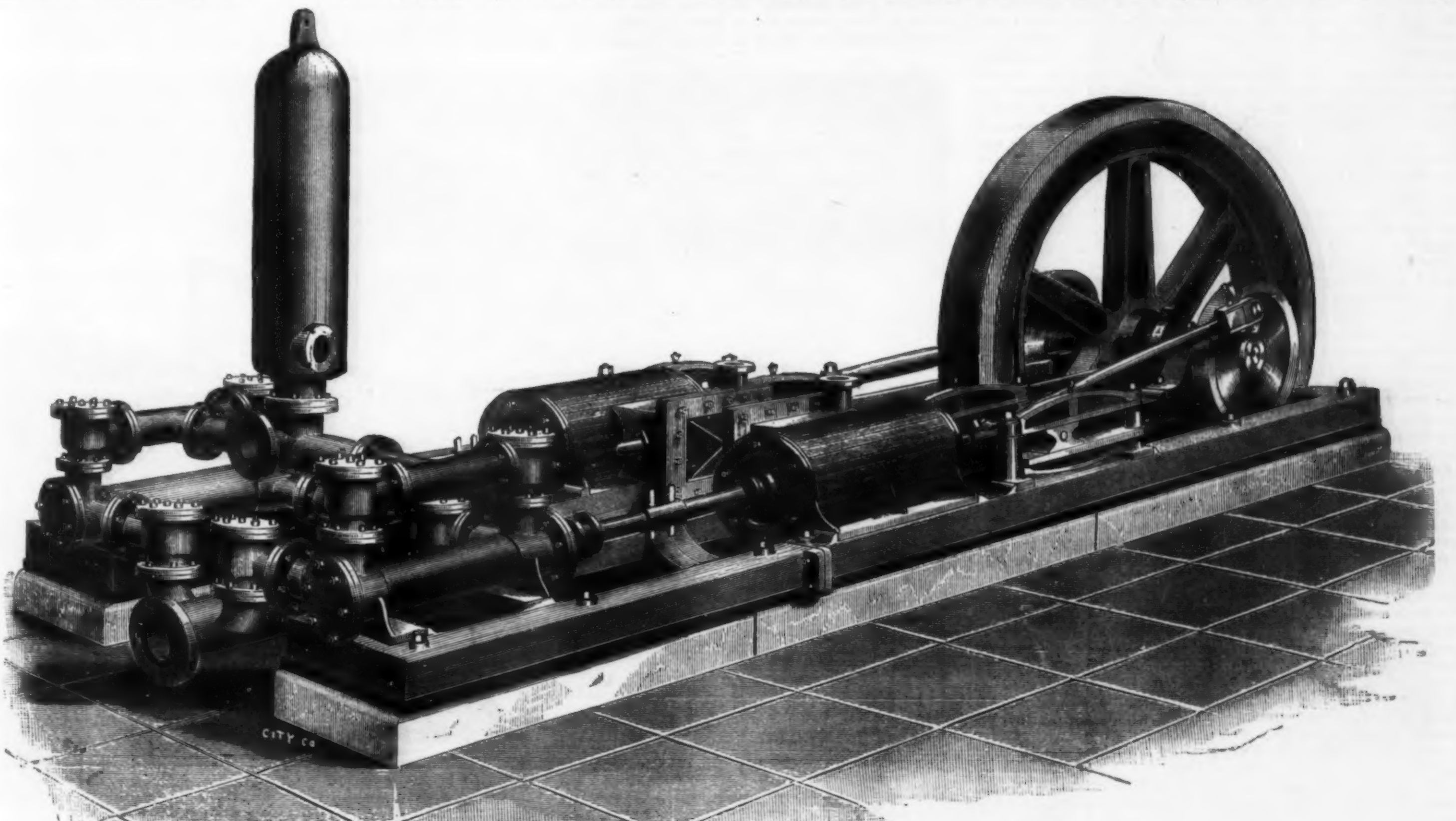
	Feet.	Inches.
Aggregate length of the two chambers in each pump	7	6
Width of the two chambers in each pump	2	3
Height of the two chambers in each pump	2	11
Capacity of each pump chamber, in cubic feet,	25	
Diameter of plunger	0	20
Diameter of rod	0	4
Area of plunger, mean of two faces	307·88 sq. in.	
Stroke of plunger	36 in.	

As a beautiful as well as most effective specimen of ma-

chinery, admirably adapted for the purposes for which it was constructed, the Gaskill pumping engines at Saratoga are well worth the critical examination of all who are interested in obtaining an efficient and economical water supply for cities and villages.

PUMPING ENGINES.

WE illustrate a pair of high pressure horizontal engines, with one pair of double-action plunger pumps, fixed behind the engines on a continuous bed, made by Messrs. Richard, Bradley and Co., Victoria Foundry, Wakefield, and designed for forcing water from the bottom of a pit to the surface. They make these engines and pumps of various sizes, but this is from photograph of a pair supplied to Messrs. John Naylor and Co., of Pildacre Colliery, Ossett. The cylinders of the engines are 14 in. diameter, having a 3 ft. stroke. The pumps are double-acting, 6 in. diameter, with inlet and outlet clack boxes, fitted with brass clacks. These engines are fixed at the bottom of the shaft, 120 yards from the surface, and running up to thirty revolutions per minute, raise 22,000 gallons of water per hour. This firm has just supplied a pair of engines and pumps of the same design as above, but with cylinders 16 in. diameter, to Strafford Main Colliery. They are fixed 200 yards from the surface. Also to Messrs. Locke and Co., of St. John's Colliery, Normanton, which engines have replaced a set of 13 in. lifting pumps, and consequently dispensed with all cumbrous spear rods and legs, etc., and which are all giving great satisfaction. The advantage of the pumps is in having long stroke, consequently less wear and tear on the valves or clacks than pumps having short strokes and running at greater speeds. All the working parts are very easily got at for inspection and repairing. These engines can also be adapted for hauling by disconnecting the pumps when not required for pumping, in which case disk couplings are supplied; or where sufficient storage of water can be provided, the engines could be economically used for hauling and pumping at the same time. In proof of the efficiency of these pumps, the same engines that were used by Messrs. Locke and Co., for working their 13 in. lifts, which were only able to deal with 150 gallons per minute, are now working two sets of these pumps direct from the piston rod end, as illustrated, and are able to deliver to the same height 300 gallons per minute. These engines, says *The Engineer*, have been running night and day since April, 1882, without having any repairs done to them whatever.



NON-CONDENSING PUMPING ENGINES, PILDACRE COLLIERY.

SIEMENS' NEW RADIATION FURNACE.

AT the recent meeting of the Iron and Steel Institute, at Chester, the following paper on "A New Method of Heating the Regenerative Gas-Furnace," prepared by Mr. F. Siemens, was read.

In every description of furnace which has hitherto been designed, either for heating or melting, it has always been considered that the first condition of successful working was to make the space to be heated as small as circumstances would allow, so that the flame might be brought into as intimate contact as possible with the inside lining of the furnace, and more especially with the material under treatment. This method of constructing and working furnaces, which was a necessary condition of success, in all cases in which it was proposed to obtain a high temperature with the use of solid fuel, was also adopted in regenerative gas-furnaces, which until quite recently were heated on the same principle. The author, however, has for some time doubted the correctness of this view; and from experience gained in the practical working of this class of furnace, after long and careful trials, has satisfied himself that they should be arranged so that the flame should only radiate heat upon the material to be heated or melted, and not come into actual contact with it, as has hitherto been the case. Further practice on the same lines has led to the development of the mode of heating to which he wishes to draw attention on the present occasion.

In the furnace as now constructed for various purposes, the gas and air ports, instead of being so arranged that the flame shall impinge upon the materials placed on the bed of the furnace, as hitherto, open at some distance below the roof of the melting chamber, and at some distance also from its side walls, so that the gas and air, after ignition, have unobstructed space for entering into combustion, and for the free development of the flame, which is kept as much as possible from contact with the roof, walls, or materials on the furnace bed; and when these are crucibles, ingots, blooms, or packets of iron, they should be placed sufficiently far apart to allow the radiant heat to have free access all around them. Where there are working doors, the flame should pass above their level. In this way the men will not be inconvenienced while watching operations inside the furnace.

But, as already mentioned, the main object to be secured is to avoid contact of the flame with the materials under treatment or with the walls of the furnace. The air inlet may be arranged above the gas inlet; thus forming two parallel horizontal ports for the delivery of the gas and air in broad streams into the furnace chamber, the inflowing air overlapping the gas at each side. Or the gas and air may be brought into the furnace chamber in several streams side by side; the air ports, which are more numerous than the gas ports, being also placed at a higher level than the latter.

In applying this method of heating to a crucible steel-melting furnace, as the length of travel of the flame is comparatively short, the gas is brought into the chamber by two ports, having an air port between them and additional air ports on either side; the ignition commencing as soon as the air and gas, which are delivered in thin streams, reach the height at which the flame is to travel across the furnace from end to end. This arrangement is one which could be applied in other cases, where, on account of the shortness of the melting chamber the air and gas have to be well mixed on ignition to secure complete combustion before their exit at the other end of the furnace. In cases in which there is a great length of travel for the flame, the ignition is retarded by means of a horizontal wall, or tongue, so that it shall only take place at the entrance of the gas and air into the furnace chamber, and the combustion may be expended throughout the furnace; the flame in this case taking a semicircular or horseshoe course.

The furnace as now built appears at first sight to be unnecessarily high and wide, but this new method of heating high-temperature furnaces by radiation requires a large space for the development of the flame, and for securing the advantages which may be obtained by its use. In order to realize the circumstances under which these benefits are obtained, it must be borne in mind that in the regenerative gas-furnace the amount of fuel used does not depend so much upon the intensity as upon the quantity of heat required; whereas in the old furnaces, in which direct combustion of solid fuel takes place, intensity can only be obtained by means of a strong chimney draught or a blast, and the consumption of very large quantities of the best fuel. Even with their use the highest temperatures required in the arts are difficult to get, and still more so to maintain; the difficulty and expense increasing with the size of the furnace.

Thus it has been ascertained that in an ordinary crucible steel-melting furnace, heated by means of solid fuel, about 2 per cent. only of the heat developed is taken up by the steel, so that nearly the whole of the great mass of coke used is expended in getting up and maintaining the furnace at steel-melting temperature. In a regenerative gas crucible steel-melting furnace, on the other hand, when once the steel-melting temperature has been reached it is easily maintained with a moderate chimney draught, and therefore by the burning of a comparatively small quantity of fuel, which may be of a poor quality, so that the greater part of the heat of combustion is taken up by the steel, while what remains amply suffices to maintain the crucibles and furnace at the necessary temperature, and only a very small quantity escapes through the chimney. The following is an actual comparison between an ordinary reheating furnace using solid fuel and one on the regenerative gas principle. The former uses about 3 tons of a fair quality of coal in a shift of 10 hours, while a regenerative furnace of equal capacity takes about two tons for the same time; there being a saving of 33⅓ per cent.

But if both furnaces are merely kept at a welding heat without any cold iron being charged, then the solid fuel furnace requires about 2½ tons of coal per 10 hours, while the regenerative gas-furnace takes ½ ton at the outside. So that when it is only necessary to maintain a certain temperature, the regenerative gas-furnace shows an economy of 80 per cent.; while it is 33⅓ per cent. when both furnaces are bringing iron up to the welding heat. The results here given are from the author's personal observation; but in some cases the advantages gained by the use of the regenerative gas-furnace for heating purposes have been greater—reaching from 40 to 50 per cent.

It is evident from the above considerations that in regenerative gas-furnaces a flame of very high temperature is obtained, such as is required for working by radiation, while the greater part of the heat so produced is taken up by the material charged; and that, therefore, there is no reason why the heating chambers of these furnaces should not be enlarged to any reasonable extent, and at the same time be built so that the flame does not come into contact either with the sides and roof or with the material to be heated. Not only does the regenerative gas-furnace lend itself to this mode of construction and of application of the flame, but experience proves that great economy in fuel is thus effected; to which must be added, in many cases, the indirect saving obtained by a considerably increased output, and the improved quality of the material produced when it is not exposed to contact with the flame, while the furnaces themselves last much longer. There can be no doubt that the very remarkable results of improved quality and increased output of material, with a longer life of the furnace, can only be brought about when the active flame is not allowed to act upon the materials within the furnace; the interruption of the process of combustion by the interposition of solid bodies always tending to injure or even to destroy them. But besides the circumstance that solid bodies are injured by flame, it can be easily shown that, when flame is brought into contact with any solid body, it is more or less quenched according to the substance, size, and temperature of the body. A very simple experiment in proof of this, and one which is familiar to most people, is the following: Take any ordinary illuminating gas flame (such, for instance, as a batswing), and place a glass rod or tube in the middle of it. The flame will immediately burn dull, and a large quantity of lamp-black will be deposited on the piece of glass. This action is most marked when the rod is cold; but takes place, though in a less degree, at any temperature, for the reason that the material to be heated is necessarily always at a lower temperature than the flame, also owing to the disturbance in the combustion caused by contact of the solid substance with the flame. I hope shortly to treat this subject more fully, from a physical point of view; but the experiments I have made establish the following most important fact, viz., that a good flame, or, in other words, perfect combustion, can only take place in an open space, or in one of sufficiently large size to allow the gases to burn out of contact with solid material.

To show more clearly the advantages which have been so far derived from the application of this new system, it will be well to give a few examples of comparative results in working regenerative gas-furnaces constructed on the old and the new principle. A glass pot furnace built at Dresden ten years ago, and which has been reconstructed for experimental purposes, shows most effectively the economy of this method of heating. This furnace held ten pots, and every night melted glass which was worked out during the

day; giving a daily production of about 3,000 bottles in a shift of seven hours, or, after allowing for pot breakages, a monthly production of 70,000 to 80,000 bottles. The pots lasted about three weeks, and the furnace itself about six months. During this time it required many repairs, which naturally interfered with its production. At present the same furnace, supplied with the same quantity of fuel, and working the same charges, produces daily 5,000 bottles in a shift of nine hours; amounting to a monthly production of 130,000 to 140,000 bottles. Fewer pot breakages also occur, less repairs are required, and the amount of waste has decreased; moreover, the glass metal is obtained from a cheaper composition than hitherto used, and proves to be of a far superior quality. The pots last fully double the time, and melt more than three times the quantity of material; while the furnace itself stands for three years—that is, it lasts six times as long, and melts more than nine times the quantity of material it did previously to its reconstruction. As the flame is kept away from the working holes, the glass-blower is able to work more at his ease, and to turn out a better product, besides being able to heat his glass in the furnace without tarnishing it. There are also several other advantages of a minor character, which, with those already referred to, enable the glass-blower to supply upward of fifty per cent. more goods without much greater exertion on his part. Another furnace, from which lamp-glass chimneys are made, gives still more favorable results. The mixture employed is much more refractory than before, and the glass produced is of a better quality and of a whiter color; while the glass-maker is now able to produce this superior kind of glass in open pots—that is, in the same manner as common glass is made. The result is that the closed pots formerly used for melting the finer qualities of glass, in order not to expose the batch or mixture to the direct influence of the flame, are no longer required, whereby a considerable saving in pots and in fuel is realized.

Similarly advantageous results are attained in the open-hearth steel-melting furnace. At the Landore Siemens Steel Works, near Swansea, the furnaces which were altered, at the end of last year and at the beginning of this, to this new method of heating have already outlasted the furnaces reconstructed upon the old type at the same time; while they work more uniformly, giving an improved and larger output owing to less oxidation of metal, as is proved by more ore being required per ton of pig iron used in order to decarbonize it to the same extent. The life of these furnaces is expected to be five or six times as long as that of the old furnaces; while great economy in the consumption of fuel per ton of steel melted should be realized. This method of heating is now being adopted at several other steel-melting works in this country, and will be found particularly advantageous where steel is intended to be made from inferior qualities of pig iron, by the adoption of a basic lining. Another important application of this method of heating is to forge, mill, and puddling furnaces; as, owing to the absence of contact between the flame and the materials with which the furnace is charged, a great reduction in the loss of metal, which has hitherto occurred through oxidation, will be effected. In steel reheating furnaces, contact of the flame with the ingots produces red-shortness in the metal, exhibiting itself in fissures, particularly at the corners of the ingots or blooms, when these are subjected to treatment either under the hammers or in the rolls. The removal of the injured portions involves a stoppage of the operations, resulting in a waste not only of material but of time also, and occasionally rendering the blooms entirely useless for the purposes intended. In the radiation furnace this cause of loss will no longer exist; while there will also be a saving due to non-oxidation of the metal. In iron reheating furnaces the gain in metal will be much more considerable than in furnaces for the reheating of steel, owing to the higher temperature at which they are worked; and the metal will weld much more easily, as it is heated out of contact with flame. These furnaces should be made as long as convenient, in order to obtain as much room as possible, for the development of the flame, and for placing the ingots, blooms, or packets sufficiently far apart to allow the radiant heat to reach them on all sides. In applying this new method of heating to puddling, it might be advantageous to erect a furnace containing a number of pans, which could either be placed in two rows, the men working at each face of the furnace, or the men could work all on one face by constructing the furnace of a horseshoe form.

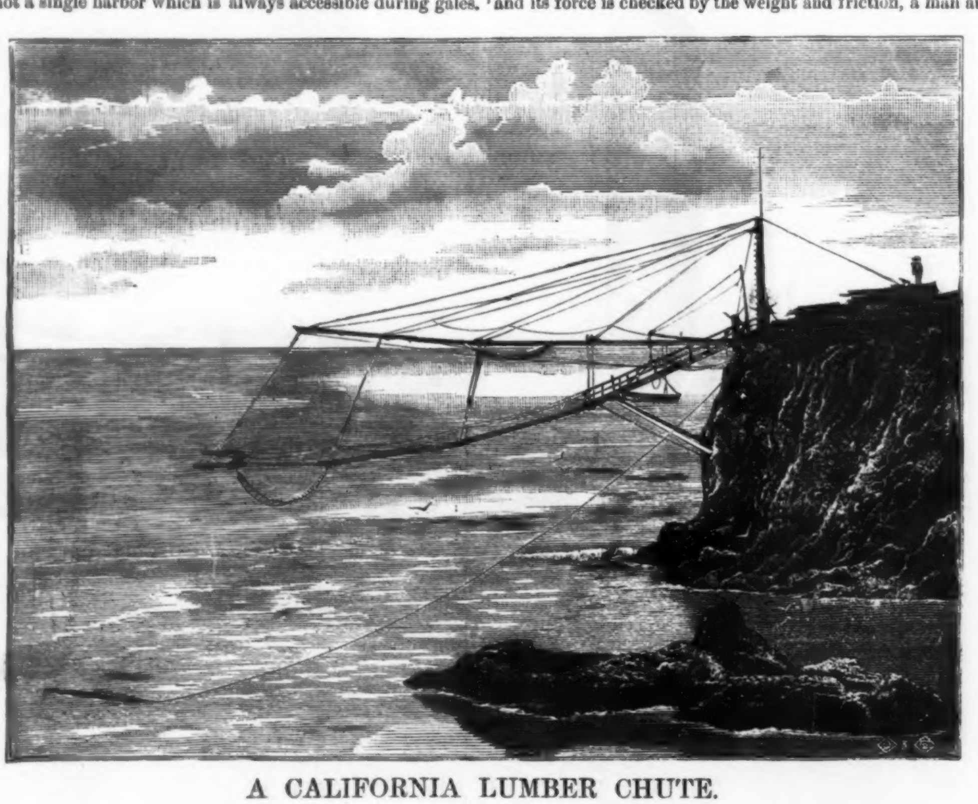
For many other applications of the new system experiments have either been prepared or trials already made; for instance, for heating boilers by means of gas. When it is considered that the temperature of the water in a boiler working at 60 lb. pressure per square inch is only 311° Fahr., while the temperature of gaseous flame may be taken at 4,000° Fahr., it will readily be perceived what a quenching effect the metal of the boiler (which is, of course, at the temperature of the water) has upon the flame. In this case the principle has been followed of letting the active flame consume itself in the open space of the tube, without allowing it to touch the sides until after complete combustion has been effected, when the products of combustion may be brought into direct contact with solid bodies. By such an arrangement complete and smokeless combustion is obtained, with the result of longer life to the boiler; the sides of which more readily deteriorate through direct contact with the flame than from any other cause. As the heat of the flame which is not transmitted by radiation comes after complete combustion into direct contact with the sides or flues of the boiler and its regenerators, it is completely utilized; and a saving of fuel to the extent of 25 per cent. is secured by this method of heating. The results obtained in actual practice show that there can be no doubt that almost all heating apparatus used in the arts, in which direct contact of flame with the substances treated is not necessary for chemical reasons, will be materially improved by the application to them of the principle of transmitting the heat of flame by radiation only, while the heat of the completely burnt products of combustion is better utilized by contact. Complete combustion of the fuel is insured by this method of heating; and it will therefore entirely abolish the smoke nuisance. Smoke is never formed when combustion is complete, being always caused by flame coming into contact with solid bodies; the process of combustion being thereby checked. This is, for instance, the reason why brick-kilns generally smoke so abominably; for in them scarcely developed flame is forced to impinge immediately on cold bricks, and can, therefore, only act in a very incomplete and uneconomical way. The author has frequently made the observation, with regard to regenerative furnaces, that a short combustion chamber invariably gives very unsatisfactory results; and accounts for it by the fact that the flame is hardly formed before it has to pass through the outlet ports and into the checker-work of the regenerators, where its combustion is checked, and smoke is formed in consequence. To work well, a brick pottery or kiln should be so built that the flame can burn itself out in a free space before being brought into contact with the bricks or pottery. Zinc-distilling furnaces—in fact, all furnaces in which muffles, tubes, crucibles, and other vessels are used—will in the same way be more economically worked on this new principle.

From these various descriptions of the regenerative gas-furnace, as now applied, it will be readily understood that the heat of the flame is utilized in two distinct conditions and periods, the one following the other. The radiation period, with its active combustion of the highest possible intensity, is limited to the furnace chamber, which is made of ample dimensions, so as to allow the flame free space to develop with obstruction to its chemical action by intervening objects; while, after combustion is at an end, and radiation ceases to be effective, the products of combustion in passing through the loose brickwork of the regenerators deposit their remaining heat by getting into close contact with the large surface of the bricks. This system of utilizing the heat of flame in two successive stages is the most economical as regards the consumption of fuel, and ought to be the ideal aimed at in all heating operations.

In conclusion, I may add that, although the regenerative gas-furnace has been well known and appreciated on account of its economy and efficiency for many years past, it will, when the principle of the exclusive use of the radiant heat of the flame to the heating chamber is applied in a thorough and efficient manner, be destined to give results which will far surpass any that have been obtained from it hitherto; and that its application in the arts will be multiplied to a degree which even its warmest admirers would scarcely have thought possible a short time ago.

LUMBER CHUTES ON THE CALIFORNIA COAST.

THE shore line of the west coast of the United States has very few good harbors. Between San Francisco and the straits of Fuca, some seven hundred miles, there is really not a single harbor which is always accessible during gales.



A CALIFORNIA LUMBER CHUTE.

There are a number of open roadsteads, giving partial shelter from the summer northwest winds, and several bar harbors, all of which are dangerous of access and utterly impracticable in heavy or even moderately bad weather.

For nearly the whole length of the northern coast, the immense forests, extending back for miles from the shore, furnish employment for labor and investment for capital. At every available point for shipment stands a saw-mill, turning trees into lumber, which is sent here by sea and thence distributed. Every little river has its fisheries and canneries, and all the valleys and bottom lands their agricultural population.

The produce is mainly shipped by sea, and under the peculiar existing conditions the people have had to devise means to overcome the natural disadvantages of the coast line. From these necessities has grown up the "chute system" of loading and discharging vessels, which it is the purpose of this article to describe. As stated, the rugged character of the coast line is such that there are few harbors or landing places where it is possible to maintain a wharf, so that chutes have to be constructed. Most of these chutes are on the coast north of San Francisco, although there are a few on the south coast also. These chutes consist of a long incline of wood in the form of a shallow trough, extending from a headland of a shipping point, or from a high wharf or pier, out to a point where water is deep enough to allow vessels to come under and load. Of course, no average can be given of their length, size, cost of construction, or length of shears. These items all depend on the location and conformation of the coast. In some cases they are 60 feet long, as when used from a wharf or pier, and in others 600 feet or more. The length depends entirely upon the vertical height from sea-level to the point from which the lumber is started. There must be inclination enough for lumber to slide by its own weight, and yet not so much that its impetus will be too great. In practice the angle is about 30 degrees, though in very long chutes it is common to give them much more pitch at the start, and have the lower end nearly level, or even ascending a little to check the force or speed of the sliding lumber. This is done for several reasons. First, in a long chute it would be nearly impossible, except at great expense, to preserve a true line of incline, and there is always more or less sag on account of the lightness of construction. Secondly, if the headland was high, it would often be impossible to obtain the correct inclination without great expense and a very long chute, perhaps too long for service, and extending clear across the harbor. It is usual, therefore, to pitch them sharp at first, and then graduate them to suit. No part of the structure ever touches the vessel, except by accident, but the whole thing is suspended from the various shears of supports, and the outer end or apron is raised or lowered to suit the stage of the tide, height of vessel, and weight of lumber, according as it is light or heavy. In stormy weather they are, of course, hoisted high in the shears.

At the lower end and close to it, say within ten or twenty feet, is a break, or "clapper," as it is usually called, which consists of a heavy flap of planks, faced smoothly with iron on its lower underneath edge. This is hinged to the top edges of chute, and the lower edge rests on the bottom. A lever handle is fastened to a frame on one side, connected to the clapper in the center with an iron bar, and extends through a similar frame on the other side, allowing the clapper to be raised on its hinges. When shipping lumber, a man is stationed at the clapper, and a couple of boards at a time are shoved down the chute. They slide down rapidly at first, and the impetus given carries them to the clapper. As they reach it the man there raises it enough to allow them to go under, and, as they slide, puts his weight on the lever, slowing them down or stopping them with their ends sticking over the vessel. The vessel is moored directly under this end, with the chute about breast high above the deck, and the boards are seized by the men and passed below or stowed on deck, as the case may be; the apron being raised as the load is put on or tide rises. This is for boards or small timber. In shipping large timber, another brake is put on higher up, consisting of several long planks held together by cross pieces on top, and hinged at the top the same as the clapper, with a rope running from the lower end through a block overhead to the upper end of the chute. As the timber runs down it goes under this flap, and its force is checked by the weight and friction, a man at the rope regulating the same, so as not to stop it altogether. When it reaches the clapper its force is so spent that the man can then stop it. It is a very nice job, all this brake business, to apply just the required amount of check at the right time, and can only be learned by experience.

These chutes are, with few exceptions, placed on the north side of the landings or coves, that side being usually the highest, with a reef extending out, which affords pretty smooth water during the prevailing northwest winds of the shipping season. The peculiar formation of the coast brings nearly all the chutes on the north side of the landings.

The engraving which we have had made to accompany this article shows a typical chute. Some are much smaller and some more elaborate. The engraving was made from a photograph of Rockport chute, Mendocino County, formerly known as Cottanueve, a landing only considered available for six months in the year, and by no means the best on the coast at any time. Nevertheless, considerable money has been spent here in improving it as a shipping point. An isolated rock off the beach, which was so precipitous and pointed as to have a foothold at its pinnacle for only one man to work at first, has been cut down until it presents a surface available for storing over 200,000 feet of lumber. From this rock to another nearer shore has been stretched a wire suspension bridge, costing over $13,000, and the horse-cars bringing lumber from the mill come on trestle-work to the bridge, and cross it to the other rock. Everything is of the most substantial character in the work done. The chute comes down from the outer rock, where the lumber is piled. There are guys, stays, and braces to steady the chute, and regulate the inclination as well.

These conditions are peculiar to the California coast, there being no other part of the world where this chute system is in vogue. They are built on all sorts of places along the coast. The extreme edge of a headland or point is often selected on account of depth of water. It must be remembered that the ocean surf is constantly rolling in, and even behind many of the small points or headlands there is a heavy swell. In many places the insurance men refuse to take risks on the vessels, on account of the danger of loss.—*Mining and Scientific Press.*

THE VENICE AQUEDUCT.

As regards drinking-water, Venice, up to the sixteenth century, had nothing but rain-water, which was stored in cisterns, and which in dry weather often gave out. Later on a canal was dug, which led water from the Brenta to Morangano, at the extreme limit of *terra firma*. Thither men went for it in large boats capable of holding about 530 gallons, and carried it to the city and put it into the cisterns. This mode of supply was practiced up to recent times. Its inconvenience and insufficiency has caused its condemnation for a long time, but the difficulties that lay in the way of introducing water directly into Venice made the city authorities pause for a long while. Finally, the "Compagnie Generale des Eaux pour l'Etranger" (formed at Paris January 20, 1879) presented itself, and submitted a project that the authorities adopted, and the Venetian "Societe de Construction," which took the work in charge, began its operations early in 1880. Let us say that in less than four years there have been constructed filtering beds, a gigantic reservoir, and the Saint Andre cistern, as well as an aqueduct sixteen miles in length that leads water to Venice, into which it is introduced by means of siphons and subterranean pipes arranged in a continuous, circular system.

At the same time a vast fountain was constructed nearly in the center of Saint Mark's Place, and this is the subject of the engraving which we present herewith. The inauguration took place on the 23d of July. In the morning the invited guests of the company, the prefect, the mayor, the senators, the deputies, and a host of dignitaries embarked upon a steamer belonging to the Societa Lagunara, at Morangano, and proceeded to visit the filtering beds, and then the gigantic Saint Andre cistern, where Cardinal Agustini, Patriarch of Venice, invoked the benediction of heaven upon this water that had been so much desired by the Venetians.—*L'Illustration.*

THE VENICE AQUEDUCT.

IRRIGATION WORKS IN ITALY.

THE irrigation system of Italy is probably the most complete in the world, and still it is constantly being increased; it forms a part of the elaborate system of defense against floods necessitated by the conformation of the Northern Provinces. According to the latest official statistics, the irrigation canals of Piedmont alone give 125,550 gallons per second, distributed over 1,340,000 acres, and those of Lombardy 95,355 gallons per second, distributed over 1,680,400 acres. These great works have not been comparatively speaking expensive. The Cavour canal, constructed within the last few years, draws its supply from the rivers Po and Dora Baltea. It gives a flow of 29,200 gallons per second, waters nearly 40,000 acres, and cost 1,600,000*l.*, about 32,200*l.* per mile. It was constructed in four years, and measures are now under consideration for increasing its debit by 5,300 gallons per second. A smaller canal subsidiary to it gives 18,540 gallons per second, and cost 24.154*l.* per mile. The largest canals are the Cavour, and its subsidiary canal just mentioned; the Muzza, and Agliano, and Naviglio Grande. The smaller of these gives 13,200 gallons per second. Below this point the canals become very numerous, and interspersed all over the country. These canals are not only used for purposes of irrigation, but also to supply motive power, by which again the water is raised to districts lying upon a higher level. On the steep slope of the Dora Baltea, not far from Turin, three canals (the Torea, Agliano, and Rotho) flow parallel to each other on different levels, while the water is used at the top of the hill, 62 feet above the highest of them. The arrangement adopted is as follows: A stream of 154 gallons per second is diverted from the Torea canal, and carried down the hill in a leaden pipe, until it meets the Agliano canal. Here it is pumped up to the summit level by eight pumps, worked by four turbines, driven by a fall of water taken from the Agliano canal, and allowed to flow down into the Rotho. By joining this latter it is used for irrigation, and thus not a drop is wasted. The great principle of Italian engineers is to work on a large scale, thus attaining at the same time efficiency and economy, avoiding constant alterations and additions; and it is by such means that the extraordinary fertility of Northern Italy is produced and maintained.

AMALGAMATING RUSTY OR FLOUR GOLD.

I AM well aware that most of the prominent authorities state as a fact, that most gold ores contain all the gold in a native state.

Nevertheless, I do not believe it.

Gold forms, by artificial means, chlorides, oxides, sulphides, etc., and so do all other metals. Why then should gold be the only metal to be always found native, while with all other metals it is the exception, and not the rule? I will admit that the compounds of gold as a class are unstable, and that its tendency is to be by itself, or native, and with half a chance it will assume that form; but without the chance how can it?

Supposing then some of the compounds of gold, the oxides, chlorides, or sulphides, to be hermetically sealed in a piece of quartz, or, to go a little further, suppose it to be a part and parcel of the rock, the same as the oxide of lead is a component part of glass,* how is it to get the chance to decompose and assume its native state?

But on the other hand, if the rock is exposed to the action of the atmosphere by being finely pulverized, or, being a surface ore, has been exposed to such an action for ages, we can readily understand how it could get the chance to decompose and come to its native state.

The action might be analogous to an iron sulphide under similar circumstances. First forming a sulphate, then an oxide, but with this difference: While iron is rarely found native, and has a tendency to form compounds, gold is the reverse, and, when a change does take place, instead of forming a compound with some other element, would assume its native state. If it is not so, how can we account for a specimen of quartz assaying rich in gold when no trace of gold can be found with the most powerful microscope?

Most gold ores contain iron to a greater or less extent, usually in the form of a sulphide. We know that the action of the atmosphere on an iron sulphide is to form first a sulphate, then an oxide; but what is the action of the sulphate on the gold in the ore? On the nuggets it has little or no action, but besides the nuggets there is the brown ore—flour or rusty gold, that in appearance and action is the same as the gold obtained by precipitating a known solution of gold by sulphate of iron. It is so fine that it has almost no specific gravity. It is of a chestnut brown color, and will not amalgamate with mercury. Like causes produce like results, and if flour or rusty gold is the same as the precipitate obtained by sulphate of iron, then the gold in the ore must have been in combination with some other element to have had the sulphate of iron acted on it the way it did. And with sulphide of iron present in the ore, it can be readily seen where the sulphate came from to act on the gold combination.

But, as I previously stated, it has so little specific gravity that the slightest agitation will cause it to float, and it won't amalgamate with mercury, that is, it won't under ordinary circumstances; but it can be made to do so by acting on it chemically, and not only the gold that is native, or in the form of a precipitate, but also any gold that may be present in the form of a combination.

My method for accomplishing this is to pulverize the ore *dry*, so as to not wash away any gold, no matter what form it may be in. Then put it in the amalgamating pan and add sufficient water to form a pulp quite thin, and inject live steam so as to heat it. I then add salt, bichloride of mercury, sulphate of copper, and glucose, and run the pan until they are dissolved and thoroughly mixed with the pulp, and the whole has become quite hot. I then add caustic soda. An action takes place at once, the glucose is oxidized by the caustic alkali, and hydrogen liberated,* which, with the assistance of the metallic iron present and the salts formed, will reduce the copper and mercury salts to a metallic state, very finely divided, and it would have the same effect on any salts of gold that might be present in solution; and at the same time the mercury and copper, being in solution, are in perfect contact with every particle of solid matter in the pulp, no matter how fine, even if they are in their atomic form. So that when the change takes place the mercury, gold, and copper form a perfect amalgam; and the specific gravity of each particle of gold is increased by the addition of copper and mercury, and is in the form of an amalgam, and in the best possible condition to unite with the body of quicksilver in the bottom of the pan. But there still seems to be a trace of oxide on the amalgam that was formed in the pulp from the mercury and copper salts. It settles in the form of a black powder, and it takes some time for it to unite with the body of the quicksilver; but by adding a little cyanide of potassium at this point, it will clear the amalgam so that it will form perfect at once. The copper in this has two effects; it not only adds to the specific gravity, but prevents the mercury from flouring. I know this to be a fact. The reason is this: The copper and mercury, both being dyad metals, they form similar compounds, only the mercury compounds are more unstable, and under like circumstances the copper will form compounds, and flour, and be lost before the mercury.

I have often had the whole mass of mercury flour as fine as calomel, and reduced it to a perfect liquid in five minutes by adding a soluble copper salt, and when there was copper enough present I could not grind it to a flour. The bullion obtained will contain copper, but it is an easy matter to separate the two.

The experiment can be done in a laboratory without the assistance of an amalgamating pan and machinery, with a test tube and the proper chemicals, by taking a few drops of gold solution and adding a little solution of sulphate of iron, which will give the brown precipitate, then add one or two iron tacks and the chemicals, and heat in the order given; or the same result will be obtained if the sulphate of iron is left out.

WM. W. WHEELER.

Meriden, Conn.

* Fownes' Chemistry, page 344.

* Fownes' Chemistry, page 464.

MODERN BRONZE ALLOYS FOR ENGINEERING PURPOSES.*

By Mr. PERRY F. NURSEY, C.E.

IN order to mark the progressive steps of man, his early history has been divided into three periods, each being named after the materials chiefly used in them for supplying him with weapons, tools, and ornaments. Thus we have the age of stone, the age of bronze, and the age of iron. To these our own times have added the age of steel, which, of course, simply means a further, but most important, development of the age of iron. It occurs to the author that in like manner a similar development is going on in the present day with respect to bronze. As, however, no generic term has been invented in these very inventive times for the new variations of that most ancient and useful alloy, he is unable to designate this fifth age by a new title, and so is content to consider it as a revival of the bronze age in a more advanced and more highly developed form. As, however, the age of stone was divided into two parts, namely, the old stone age, when men simply chipped stones, and the newer stone age, when they learned to grind and polish them, so perhaps it may be admissible to consider the present as the newer bronze age. Nor is it altogether inapt so to consider it when we see what a many varieties of bronze have been produced within the last few years possessing very distinctive features from the ancient alloys, and some very remarkable qualities as compared with them, and how very numerous the purposes are to which these varieties are applied, superseding, as they do in many instances, iron, and even steel itself. These considerations, and the knowledge of the great value of these alloys to the engineer and the shipbuilder, have led the author to bring a few facts concerning them before the society, in the hope that they may prove interesting and possibly useful to the members.

Although, for the purpose of drawing a fanciful parallel between the past and the present, the author has taken his hearers back to the childhood of the world, when men first mixed and melted copper and tin together, and fashioned in a rude way from the resulting alloy their spear-heads, their hatchets, their earrings, and their bracelets, he does not intend to fill up the gap formed by the intervening centuries by following up the gradations by which this alloy was made at length to subserve the highest purposes of art, which, as regards statuary, probably reached a climax during the reign of Alexander the Great. He purposes only to touch upon a few points of metallurgical interest relating to the bronze of the past, and then by a rapid transition to come down to the present, and to enter upon a consideration of the various alloys of the bronze family which the ingenuity of our own day—stimulated, doubtless, by the necessities of the age we live in—has succeeded in rendering available for engineering purposes during the last few years.

Turning then, briefly, to the bronzes of the ancients, we find them varying considerably in the proportions of their two ingredients—for in the main copper and tin only were used—according to the purposes for which they were intended. Thus, modern chemical analysis shows that ancient bronze nails contained 20 of copper to 1 of tin; soft bronze consisted of 9 to 1, medium bronze 8 to 1, hard bronze 7 to 1, and mirrors about 2 to 1. The bronze weapons and tools of the ancients contained from 8 to 15 per cent. of tin. A Roman sword blade found in the Thames showed 85·70 copper and 10·02 tin, while another one found in Ireland gave on analysis, copper 91·39 and tin 8·38. The bronze weapons of the Greeks and Romans have been found not only to be of the true composition for insuring the greatest density in the alloy itself, but the cutting edges, by undergoing a process of hammering, were brought up to the highest degree of hardness and tenacity. And here the author would digress for one moment to observe that this is exactly the way in which he has seen the edges put on scythe blades and other cutting tools in Styria, where he has seen some of the finest steel made in the simplest and rudest manner. Returning to the subject of the paper, it is to be observed that most of the ancient coins were of bronze, a small percentage of zinc being added in some cases to improve the color. According to analyses made by Mr. J. A. Phillips, the quantity of tin relatively to copper varied very slightly, even over a range of 300 years. The following are the proportions of copper and tin, the other ingredients being omitted:

Coins.	B.C.	Copper.	Tin.
Alexander the Great	335	86·72	13·14
Philippus V.	200	85·15	11·10
Athens	—	88·41	9·95
Ptolemy IX.	70	84·21	15·59
Pompey	53	74·11	8·56
The Atilia family	45	68·72	4·77
Augustus and Agrippa	30	78·58	12·91

Bronze pure and simple consists of a mixture of copper and tin in certain proportions. These proportions, as we have seen, are varied according to the purpose for which the compound is intended. Other metals, moreover, such as zinc, lead, phosphorus, manganese, silicium, and iron, may be and have been added without unclassifying the product, which is still called bronze, provided that copper and tin are the chief constituents. The bronzes of France are known to contain nearly always four metals—namely, copper, tin, lead, and zinc. It is also stated that some contain minute and variable quantities of nickel, arsenic, antimony, and sulphur. It is the addition to bronze pure and simple of certain proportions of one or other of the metallic substances previously referred to that constitutes the modern development of bronze manufacture, and which has given us some of the most useful and at the same time some of the most remarkable alloys known. These comprise no fewer than eleven distinct products, all of which find their uses in connection with the practice of engineering. These are—phosphor bronze; silicium bronze; manganese bronze; delta metal; phosphor copper; phosphor-manganese bronze; phosphor-lead bronze; phosphor tin; aluminum bronze; silveroid; and cobalt bronze. These alloys form the subject for present consideration, and they will be dealt with by the author in the foregoing order. There are other bronzes which are used as substitutes for gold in cheap imitation jewelry; but although they are in the main only variations of some of the bronzes with which the author has to deal, their applications are such that their notice does not fall within the scope of the present paper.

Attention was directed some years since to the use of phosphorus in improving the character of bronze for various purposes, and eventually with very successful results. The action of phosphorus on copper alloys is principally due to its reducing qualities, by virtue of which the oxygen absorbed by the molten metal is removed, or rather the oxides thereby produced are eliminated, and there is imparted to the metal that degree of homogeneity, strength, and toughness which is peculiar to the chemically pure metal. The phosphorus by producing these effects is converted into cuprous oxide, which floats on the surface of the molten metal in the shape of a very fluid slag, while the superfluous quantity combines with the metal. This being the case, it is not desirable to add to the bronze a larger quantity of phosphorus than will suffice to reduce the oxide present. It is thought by some that the phosphorus itself imparts to the bronze the qualities of hardness and strength, and that therefore the more phosphorus put into the metal the better the result as regards hardness. This, however, is not the case, inasmuch as hardness would be obtained at the expense of toughness. The question of producing the various qualities of this class of metal depends not so much upon the quantity of phosphorus as upon the correct proportioning of the various ingredients, phosphorus included. Some of the alloys to which the author will direct attention are formed by the addition of a small proportion of a compound of phosphorus and copper or other metal to the bulk of the copper to be treated. Inasmuch, however, as great care is

TABLE I.—RESULTS OF EXPERIMENTS TO ASCERTAIN THE ELASTIC AND ULTIMATE TENSILE STRENGTH OF TWELVE PIECES OF PHOSPHOR-BRONZE, SIX PIECES OF ORDINARY BRONZE, AND ONE PIECE OF BRASS.

Description.	Stress.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture	Extension sets at	
	Elastic per Square Inch.	Ultimate per Square Inch.			Lb. 20,000 per Square Inch.	Ultimate.
	Lb.	Lb.	Per cent.	Per cent.	Per cent.	Per cent.
Phosphor-bronze	23,800	40,876	58·2	3·9	0·40	3·8
" "	21,900	40,865	43·9	9·8	0·09	10·6
" "	19,800	33,623	58·9	5·9	0·18	4·6
" "	15,400	24,193	63·6	7·9	1·94	6·7
" "	14,900	21,755	68·5	5·9	2·26	4·3
" "	13,700	25,715	53·3	9·8	3·12	10·9
" "	21,400	35,024	61·1	5·0	0·11	3·6
" "	19,200	43,032	44·6	15·1	0·26	14·1
" "	16,100	44,448	36·2	31·9	0·98	33·4
" "	13,400	36,044	37·2	19·9	1·52	16·5
" "	11,800	24,988	47·2	13·4	5·13	11·1
" "	10,700	34,024	31·5	23·0	3·06	17·4
Ordinary bronze	19,700	29,534	66·7	8·4	0·18	4·0
" "	19,600	27,376	71·6	5·0	0·18	2·6
" "	17,800	22,592	78·7	5·0	0·72	2·3
" "	17,700	21,946	80·7	3·3	0·50	1·6
" "	17,600	20,482	85·9	1·5	0·68	1·2
" "	16,400	20,296	80·8	3·3	1·10	1·7
Brass	10,100	27,518	36·7	18·3	5·80	16·1

TABLE II.—RESULTS OF EXPERIMENTS TO ASCERTAIN THE TENSILE STRENGTH AND THE RESISTANCE TO TORSION OF VARIOUS WIRES.

Description.	Pulling Stress. Wires as Drawn.				Twists in 5 Inches.	
	Diameter.	Area.	Stress.		As Drawn.	Annealed.
			Total.	Per Square Inch.	Mean of Three.	Mean of Three.
	Inch.	Square inch	Lb.	Lb.	Twists.	Twists.
Phosphor-bronze	0·0655	0·003367	340	100,980	5·0	91
" "	0·0640	0·003216	389	120,957	22·3	52
" "	0·0600	0·002827	352	124,313	7·0	87
" "	0·0610	0·002922	379	129,705	8·3	98
" "	0·0595	0·002778	336	120,950	13·0	124
" "	0·0585	0·002655	395	147,113	7·5	97
" "	0·0640	0·003216	513	159,515	13·3	66
Copper	0·0640	0·003216	203	63,122	86·7	96
Brass	0·0605	0·002871	233	81,156	14·7	57
Steel (ordinary)	0·0600	0·002827	342	120,976	22·4	79
Iron, galvanised, best best C	0·0580	0·002643	170	64,321	26·0	44
" " best charcoal E	0·0580	0·002643	174	65,834	48·0	87

TABLE III.—RESULTS OBTAINED WITH VARIOUS AXLE BEARINGS.

Kind of Bearing.	Composition in 100 Parts Alloy	Comparative Cost of 100 Kilos. Bearings inclusive of Melting Expenses, Loss, &c.	1 Kilo. Bearing Metal Runs.			Cost of Bearing Metal per Waggon with 4 Bearings per 100 Kilometres.	Names of Railroads where used.
			German Miles.	Kilometres.	Wear per 100 Kilos. for 4 Bearings		
		Marks.			Grammes.	s. gr.	
Gun metal ...	83 copper, 17 tin	260·20	12,052	90,390	11·60	0·301	Austrian Railway.
" " ...	82 " 18 "	260·80	13,320	99,900	10·01	0·260	Grand Central Belge.
White metal	3 copper, 90 tin, 7 antimony	298·68	9,104	78,280	14·64	0·395	Austrian Railway.
" " ...	5 copper, 85 tin, 10 antimony	293·40	11,750	88,145	11·35	0·331	Niederschlesisch-Märkische Bahn.
Lead composition...	84 lead, 16 antimony ...	118·56	10,338	81,280	12·30	0·145	Austrian Railway.
Phosphor-bronze ...	—	360	57,226	429,200	2·33	0·081	Grand Central Belge.
Gun metal on brake cars ...	82 copper, 18 tin	260·80	1,218	9,134	109·48	2·844	" " "
Phosphor-bronze on brake cars ...	—	350	14,320	107,410	9·31	0·325	" " "

TABLE V.—TESTS OF MANGANESE BRONZE BY TENSILE STRAIN.

No.	Description.	Where tested.	Elastic Limit.	Breaking Strain.	Ultimate Elongation.	Remarks.	
			Tons per sq. in.	Tons per sq. in.	Per cent.		
1	No. 1 rods rolled hot	R. G. F.	11·00	29·00	44·6	Mild, annealed for rivetting cold.	
2		U. C. L.	13·17	29·29	33·4	Annealed.	
3		Do.	23·54	31·60	26·5	As delivered from the rolls.	
4		Do.	24·32	31·43	23·3		
5		R. G. F.	34·40	39·60	11·6	Ditto, and finished cold.	
6	No. 1 plates rolled hot	R. G. F.	14·06	28·46	23·2	Pulled across fibre.	Annealed.
7		Do.	14·06	30·13	47·8	Pulled with fibre.	
8		Do.	14·80	30·78	34·1	Pulled across fibre.	
9		Do.	16·70	30·10	28·8	Pulled with fibre.	
10	No. 2 cast under pressure	M. B. & B. Co.	18·00	35·00	22·0	Cast in an iron cylinder and pressed while liquid.	
11		Do.	16·23	31·90	12·4		

No. 10 cut from side of ingot, and No. 11 from centre.

* Paper read before the Society of Engineers, October 6, 1884.

TABLE VI.—TESTS OF MANGANESE BRONZE BY TORSION.

	Description.	Where tested.	Diameter.	Twisting Moments. Elastic Limit.	Twisting Moments. Breaking Strain.	Amount of Twist in Length of One Diameter.	Remarks.
			Inch.	Inch-lb.	Inch-lb.	No. of Turns.	
1	No. 2 cast under pressure	U. C. L.	0·622	1,170	3,360	0·183	Uniform twist.
2	No. 2 cast under pressure ...	Do.	0·624	1,200	3,372	0·166	Do.
3	No. 1 rolled ...	Do.	0·621	1,110	2,880	0·175	Annealed.
4	Rod...	Do.	0·621	1,980	3,242	0·165	Rolled hot, and tested as it came from rolls.

No. 3 was removed from machine unbroken. No. 4 was broken showing a clean shear.

TABLE VII.—TEST OF A BAR OF MANGANESE BRONZE NO. 3 BY TRANSVERSE STRAIN.

(Bar 1 inch square, cast in sand, placed on supports 12 inches apart; steady pressure applied in middle of bar.)

Strain.	Deflection, Strain on.	Permanent Set, Strain off.	Strain.	Deflection, Strain on.	Permanent Set, Strain off.
Lb.	Inch.	Inch.	Lb.	Inch.	Inch.
896	0·025	—	2,688	0·21	0·12
1,120	0·03	—	3,136	0·44	0·34
1,344	0·04	—	3,584	0·86	0·73
1,568	0·045	—	4,032	1·62	1·44
1,792	0·06	0·005*	4,144	1·97	—
1,904	0·065	0·01*	4,256	Gave way without breaking, and bent to a right angle.	

* Elastic limit.

TABLE VIII.—EXPERIMENTS ON THE TRANSVERSE STRENGTH AND TOUGHNESS OF BARS OF MANGANESE BRONZE AS COMPARED WITH WROUGHT IRON AND GUN METAL, MADE BY DROPPING A WEIGHT ON THE MIDDLE OF THE BAR RESTING ON SUPPORTS AT EACH END.

(Weight of monkey, 50 lb.; height of fall, 5 feet; distance between supports, 1 foot; dimensions of bar, 1 inch square, 14½ inches long.)

No. of Blows.	Permanent Deflection in Inches, in the Length of 12 Inches.											
	Wrought Iron.		Gun Metal.						Manganese Bronze.			
	Staffordshire Rolled.		Cast in Sand.						No. 3 Cast in Sand.		No. 1 Forged.	
	No. 1.	No. 2.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 3.	No. 4.	No. 5.	No. 6.
1	0·57	0·58	0·82	0·86	0·90	0·72	0·73	0·46	0·66	0·60	0·59	0·60
2	1·10	1·15	1·50	1·58	1·63	1·32	1·42	and	1·20	1·15	1·06	1·08
3	1·62	1·71	1·70	2·22	2·35	1·92	1·52	broke	1·70	1·60	1·44	1·50
4	2·13	2·23	and	and	2·86	1·94	and	—	2·23	2·07	1·80	1·89
5	2·65	2·77	broke	broke	and	and	broke	—	2·67	2·52	2·12	2·26
6	3·19	3·37	—	—	broke	broke	—	—	3·11	2·97	2·45	2·65
7	3·77	3·99	—	—	—	—	—	—	3·58	3·39	2·77	2·99
8	4·39	4·63	—	—	—	—	—	—	4·02	4·04	3·05	3·38
9	not broken		—	—	—	—	—	—	not	and	3·33	not
10			—	—	—	—	—	—	broken	broke	not	broken
11			—	—	—	—	—	—	—	half	broken	—
12			—	—	—	—	—	—	—	through	—	—
13			—	—	—	—	—	—	—	—	—	—

TABLE IX.—EXPERIMENTS WITH ROLLED ROUND BAR OF DELTA METAL TO ASCERTAIN THE TENSILE, CRUSHING AND TORSIONAL STRENGTH.

TENSILE TEST.

Original Diameter.	Original Area.	Original Length.	Elastic Limit per Square Inch.	Commencement of Permanent Set per Square Inch.	Ultimate Stress per Square Inch.	Elongation.	Contraction of Area of Fracture.
Square inch.	Square inch.	Inches.				Per cent.	Per cent.
0·795	0·497	10·0	31,575 lb. = 14·1 tons	40,757 lb. = 22·2 tons	80,658 lb. = 37·34 tons	12·9	17·4

CRUSHING TEST.

Original Diameter.	Original Area.	Original Length.	Compression by a Stress of Lb. 22,000	Lb. 44,000	Lb. 66,000	Lb. 77,000	Lb. 88,000	Lb. 99,000	Lb. 110,000	Lb. 121,000	Lb. 132,000	Ultimate Stress per Square Inch.
Inch. 1·19	Sq. in. 1·11	Inch. 1·19	0·80%	1·33%	2·03%	2·71%	3·87%	5·77%	8·20%	10·76%	13·41%	Lb. 135,700 = 60·5 tons

TORSIONAL TEST.

(Twisting measured in degrees. Length of lever = 1 foot.)

Original Diameter.	Original Area.	Original Length.	Stress applied in lb. 4·137	8·274	12·41	14·48	16·45	20·686	28·961	37·236	45·51	53·78	60·0
Inch. 0·394	Square inch. 0·1227	Inches. 10·24	1° 5′	4° 0′	6° 5′	8° 48′ Elastic limit.	10° 0′	16° 5′	70° 0′	242°	486°	794°	Fracture.

required in determining the exact proportions of the ingredients in making phosphor-bronze alloys, it appears to the author that it would be much safer and probably much more economical for manufacturing engineers to obtain the alloys ready prepared for the special purpose for which they require them, and which would, other things being equal, obviate all chance of failure by reason of a careless workman adding too little or too much of the phosphorized metal to the bulk.

PHOSPHOR BRONZE.

The first of the modern bronzes for notice in the order of time is phosphor bronze, which was invented by Dr. Künzel, of Blasewitz, Dresden, and was brought into practical use in this country early in 1873 by the Phosphor Bronze Co., who have from time to time patented several improvements both as regards alloys and methods of manufacture. Phosphor-bronze alloys are composed of copper, tin, phosphorus, and other ingredients in definite proportions, and are made to be either as ductile as copper, as tough as iron, or as hard as steel, accordingly as the proportions of the constituents are varied. The alloys used for rolling and drawing have very different proportions to those employed for castings, for bearings, and parts of machinery. The castings of the metal, owing to its great fluidity when melted, are perfectly sound and homogeneous. Wherever strength, toughness, and durability are desiderata, phosphor-bronze is found to be far better adapted than gun metal and brass, and in many cases than iron and steel. With regard to the applications of phosphor-bronze, it may truly be said that their name is legion. This remark applies in the main to most of the modern bronze alloys presently to be described, so that, in order to save repetition, the author will here observe that chief among their many applications are the manufacture of wire, rods, tubes, sheets, ornamental castings, screw propellers, pinions, cylinders, valves, bearings, bushes, and other parts of machinery exposed to friction. Phosphor bronze possesses the advantage of not becoming crystalline under the action of repeated shocks and bends, and is therefore well adapted for making wire rope; and as it is not acted on by corrosive liquids, as found in mines, or by the atmosphere, its value as a metal remains constant. It is being used in the shape of sheets for the hulls of torpedo boats and steam launches with satisfactory results. In order to ascertain its resistance to the chemical action of dilute sulphuric acid, two similar sheets of copper and of phosphor bronze were immersed in acid water 10° Baume strength, and at the temperature of the surrounding atmosphere; after three months it was found that the copper had lost 4·15 per cent. and the phosphor bronze only 2·3 per cent. Phosphor bronze sheet, moreover, stands the action of sea-water much better than copper. In a comparative experiment made at Blackenberghe, lasting over a period of six months, between the best English copper and phosphor bronze, the following results were arrived at: The loss in weight due to the oxidizing action of sea-water averaged for the copper 3·058 per cent., while that of phosphor-bronze was but 1·158 per cent.

In making castings from phosphor-bronze alloys, a new or clean plumbago crucible is used, so as to avoid any admixture of other metals, and some charcoal or coke is kept on the metal during the melting to prevent oxidation. For large castings the moulds are thoroughly dried and dressed with a mixture of blacklead and water. Small work is cast green. In order to avoid segregation, it is necessary to pour phosphor bronze alloys only just before the setting takes place. This is accomplished by cooling the molten metal by putting in ingots or runners, and when the metal no longer melts these, but adheres to them, it is a sign that the pouring should take place. Previously to pouring, the molten mass is well stirred by means of an iron rod covered with a paste of either fireclay or plumbago. Besides the original phosphor-bronze with which the author has dealt so far, the Phosphor Bronze Company a year or two ago brought out two other varieties. These were the outcome of an endeavor on the part of the company to meet as far as practicable the various requirements of engineers and millwrights, particularly in connection with parts of machinery exposed to combined friction and pressure. By slightly changing the proportions of the component parts of some of the ordinary mixtures, new alloys having very valuable and distinct characteristics have been produced, and which have been practically tried and proved. These new alloys are known as phosphor bronze duro A and phosphor bronze duro B. Duro A is a very dense metal, adapted for all bearings carrying heavy wheels running at great velocities, and generally for all quick-speed purposes. Duro B is intended for the bearings of hot-neck rolls, and for all bearings having to withstand great pressure, such as plate and sheet roll bearings and for general engine purposes.

Having referred to the great durability of phosphor bronze under conditions of work, the author will here notice one instance out of several which have been brought under his notice from time to time. About two years since he inspected a pair of slide valves, which had been then recently taken out of one of the North-Eastern Railway Company's express engines after six and a half years' working, during which the engine had run 261,182 miles between Newcastle and Edinburgh. They were taken out to replace the cylinders with a pair of a different type.

The engine was of the following dimensions: Cylinders, 17 inches diameter by 24 inches stroke; four coupled wheels, 7 feet diameter; working pressure, 140 lb. per square inch; weight of engine in working trim, 39 tons 16 cwt.; weight of tender, 26 tons 4 cwt.

Mr. Fletcher, the assistant locomotive superintendent of the North-Eastern Railway, states that the slides, in the six and a half years, had only worn down to the thickness at which they generally took out gun-metal slides, and that, had it not been that they were putting in a pair of cylinders of different type, he would certainly have let them run longer, as he considered them quite safe, taking into consideration the great superiority of phosphor bronze over gun-metal. The original thickness of these slides was 1 inch, and they were worn down to ⅝ inch thick. Gun-metal slides rarely exceed eight months' work, when they are worn out. The cylinder faces were in excellent condition, the wearing being, as it should be, on the valves.

Tables I. and II. give the results of some comparative experiments made by Mr. David Kirkaldy with phosphor-bronze and various other alloys and metals, while Table III. gives the results of tests made with axle bearings of various metals

SILICIUM BRONZE.

We come in the next place to silicium bronze, which in some respects may be considered as an outcome of phosphor bronze, although its invention is not due to Dr. Künzel, who died some years ago. The inventor is M. Lazare Weiller, of Angoulême, who exhibited phosphor bronze telegraphic and telephonic conductors at the Paris Electrical Exhibition of 1881, where the author first saw them, and where they were novelties. M. Weiller carried out an exhaustive series of experiments with this wire, the results of which went to show that it possessed a conductivity one-third that of copper, but 2½ times that of iron and steel. Phosphor bronze wires, therefore, proved very useful for telephonic communication, but not for telegraphic purposes, where higher conductivity is required. M. Weiller, therefore, set himself the task of discovering a material analogous to phosphor-bronze, and his labors were at length crowned with success by the discovery of silicium bronze. In this alloy the phosphorus is replaced by a silicious metalloid which produces a better conductor than does phosphorus. M. Weiller thus obtains a wire presenting the same resistance to rupture as phosphor bronze wire, but with a much higher degree of conductivity, rendering it applicable for

telegraph lines, and bringing the valuable qualities of lightness and non-oxidizability within easy and economical reach. In a paper upon electrical conductors, read by Mr. W. H. Preece, F.R.S., before the Institution of Civil Engineers, in December, 1883, that gentleman observed in reference to phosphor and silicium bronze wires that in their manufacture phosphorus and silicium had the property of removing impurities, particularly the oxides, though doubtless some of the flux remained. Phosphorus had a most injurious influence on the electrical resistance of the alloy. Silicium was far superior; hence the silicium bronze was preferable for telegraphic purposes. Its efficiency was very great; in fact, phosphor bronze had disappeared for telegraph wire, and had been replaced by silicium bronze. It is important to note that the properties of this alloy are such that, although the wires are only one-tenth as heavy as the ordinary wires, they are of equal strength. Moreover, it is affirmed that, if broken, they will not fall to the ground as the ordinary wires do, but by reason of their high elasticity they will spring back and coil up close to the standards. The author should mention that M. Weiller has associated himself with the Phosphor Bronze Company, who are manufacturing silicium bronze wire, which, the author is informed, has come largely into use for overhead telephone lines, and proves a satisfactory substitute for the cumbrous iron wire. This table shows the relative strength, resistance, and conductivity of various wires.

Description of Wire.	Tensile Strength per Square Inch in Tons.	Resistance per Mile in Ohms.	Relative Conductivity.
Pure copper	17·78	33·1	100
Silicium bronze (telegraph)	28·57	34·5	96
Silicium bronze (telephone)	48·25	103	34
Phosphor bronze (telephone)	45·71	124	26
Swedish galvanized iron	22·86	216	16
Galvanized Bessemer steel	25·40	249	13
Siemens-Martin steel	26·67	266	12

MANGANESE BRONZE.

The author now comes to that class of bronzes into the composition of which iron in one form or other enters, and of which there are two principal varieties, namely, manganese bronze and delta metal. It is stated that some of the ancient bronzes have been found on analysis to contain a small percentage of iron, but it does not appear that any traces of manganese have ever been discovered. It is thought probable that the ancients knew that the addition of iron to bronze would increase its hardness, and introduced it for that purpose. Modern inventors have proposed combinations of iron with brass alloys, and some have also introduced manganese by reducing the black oxide of manganese and combining it with the copper. Until a comparatively recent date, however, none of these alloys appear to have been brought into permanent practical use. More than a hundred years since, James Kier proposed an alloy of 10 parts of iron with 100 parts of copper and 75 parts of zinc, and in later times Sir John Anderson, when superintendent of the Royal Gun Factories, carried out a number of experiments with similar alloys, and with some very good results, but none of them appear to have been brought into practical use. The addition of iron unquestionably increases the strength and hardness of these alloys, but, according to some experiments made by Mr. P. M. Parsons, they would appear to acquire these qualities at the expense of ductility and toughness, and it is probably on this account that this class of alloys had not come into general use up to the time of Mr. Parsons' experiments. Mr. Alexander Parkes and the late Mr. J. D. Morries Stirling, both eminent metallurgists, appear to have been the first to propose and to carry into practice the use of manganese. Mr. Parkes combined manganese alone with copper, and used this alloy to form improved alloys of brass and yellow metal of which to make sheathing, rods, wire, nails, and tubes.

Mr. Stirling in 1848 proposed to use manganese, in various brass alloys in which iron was present. At first he combined about 7 per cent. of iron with the zinc, and added to the copper a small percentage of manganese, by reducing the black oxide of manganese with the copper, in the presence of carbonaceous materials, and then added to it the requisite quantity of the iron and zinc alloy to make the improved brass required. Mr. Stirling's idea was to combine the iron with the zinc by fusion, but in practice he found a more ready means of procuring the zinc and iron alloy by employing the deposit found at the bottom of the tanks for containing the melted zinc for galvanizing iron articles. This product consists of zinc with from 4 to 6 per cent. of iron, but this percentage is very variable, and the results of its use, therefore, in some cases unreliable. The author is informed that metal made by this process was in use for some time for carriage bearings, on the London and North Western and other railways, with very good results; but it has long since been superseded, and does not appear to have ever been introduced for any purposes where the requirements were great strength, hardness, and ductility.

The time, however, arrived, namely, in 1876, when these requirements were met by the aid of manganese in the manganese bronze of Mr. P. M. Parsons. This alloy is prepared by mixing a small proportion of ferro-manganese with copper, and which is afterward made into alloys similar to gun metal, bronze, brass, or any other alloy of which copper forms the base. The ferro-manganese is melted in a separate crucible, and is added to the copper when in a melted state. The effect of this combination is similar to that produced by the addition of ferro-manganese to the decarburized iron in a Bessemer converter. The manganese in a metallic state, having a great affinity for oxygen, cleanses the copper of any oxides it may contain, by combining with them and rising to the surface, in the form of slag, which renders the metal dense and homogeneous, as already explained by the author in respect of phosphorus. According to Mr. Parsons, a portion of the manganese is utilized in this manner, and the remainder, with the iron, becomes permanently combined with the copper, and plays an important part in improving and modifying the quality of the bronze and brass alloys, afterward prepared from the copper thus treated. The effect is greatly to increase their strength, hardness, and toughness, the degrees of all of which can be modified, according to the quantity of the ferro-manganese used, and the proportions of the iron and manganese it contains.

It will thus be seen that Mr. Parsons' method of making manganese bronze is altogether different, both in principle and effect, from the inventions of either Parkes or Stirling. Stirling's method of combining the iron with the zinc, in order to introduce it into the alloys, precludes its use in any but those alloys in which a considerable portion of zinc is employed, such as brass or yellow metal. It could not be applied to any of those important alloys, of the nature of gun metal or bronze, in which copper and tin are the chief ingredients. An equal important difference in the manufacture of manganese bronze consists in adding the manganese in its metallic state, in the form of ferro-manganese, to the copper, by which the copper is cleansed from oxides, which it cannot be when the manganese is reduced from the black oxide and combined with the copper by one and the same operation, as was done by Parkes and Stirling. Another point of importance is the great nicety with which both the iron and manganese can be adjusted, and their effect controlled by adding the ferro-manganese to the copper, as pursued in the manufacture of manganese bronze. The amount of manganese required for deoxidizing the copper, and for permanent combination with it, being well known by experience, it is found that very slight variations in quantity have a perceptible and ascertained effect in modifying the qualities of the alloys produced. The toughness can be increased, and the hardness diminished, or *vice versa*, at will, precisely as is done in the manufacture of steel, by increasing or diminishing the percentage of carbon and manganese. In preparing the ferro-manganese for use, Mr. Parsons prefers that which is rich in manganese, containing from 50 to 60 per cent. This is melted with a certain proportion of the best wrought-iron scrap, so as to bring down the manganese to the various proportions required. At the same time any silicon it contains is reduced, and the metal refined. About four qualities of ferro-manganese are made in practice, containing from about 10 to 40 per cent. of metallic manganese. The lower qualities are used for those copper alloys in which the zinc exceeds the tin, and the higher qualities for those in which tin is used alone, or exceeds the zinc used in combination; and the amount of ferro-manganese added varies generally from about 2 to 4 per cent. After a number of careful experiments and crucial tests, the Manganese Bronze and Brass Company, who are the sole manufacturers of manganese bronze, adopted the manufacture of five different qualities of this alloy, although other varieties can be produced for special purposes. In No. 1 quality the zinc alloyed with the copper is considerably in excess of the tin. It is cast into ingots in metal moulds, and then forged, rolled, or worked hot, and made into rods, plates, sheets, sheathing, and it may also be worked cold, and drawn into tubes and wire. When simply cast, it is stated to possess a tensile strength of about 24 tons per square inch, with an elastic limit of from 14 to 15 tons. When rolled into rods or plates, it has a tensile strength of from 28 to 32 tons, with a limit of 15 to 23 tons per square inch, and it stretches from 20 to 45 per cent. of its length before breaking. When rolled cold, the elastic limit rises to over 30 tons, and the breaking strength to about 40 tons, and it still elongates about 12 per cent. before breaking.

Manganese bronze No. 2 is similar to No. 1, but stronger, and it can be cast in sand for special purposes where strength, hardness, and toughness are required. But it must be melted in crucibles, as passing it through the reverberatory furnace injures the metal, and causes unsound castings. It is not, therefore, adapted for general brassfounders' purposes. One of the most important applications of this quality is that of producing articles cast in metal moulds under pressure. Blocks of this metal thus simply cast are said to have all the characteristics of forged steel as regards strength, toughness, and hardness, without any of its defects. It is perfectly homogeneous, and while not possessing a fibrous texture derived from rolling or hammering, it is still fibrous in character, and this in not one but in all directions alike, and, when broken, shows a beautiful silky fracture. Its tensile strength is from 32 tons to 35 tons per square inch, and its elastic limit from 16 to 22 tons, with an ultimate elongation of from 12 to 22 per cent.

Another feature of No. 2 quality is that it can be cast on to any object, and will shrink on to it with a force equal to its elastic limit, and, when released, will show an amount of resilience of about double that of steel. As an instance of this, the author is informed that a hoop of this manganese bronze, shrunk on to a solid cylinder of iron, stretched, when hot, 0·03 of its diameter in the process of contraction, and, when cold and released, sprang back about 0·003 of its diameter. As regards hardness, it is about equal to mild steel. In order to ascertain its efficiency in this respect, and to compare it with gun metal, wrought iron, and steel, a knife-edged angular die was forced into the flat surface of a piece of each of these metals, and of the No. 2 manganese bronze cast under pressure. In order to produce an indentation of equal depth in each of these specimens, the following pressures are required:

	Cwt.
Gun metal	12
Wrought iron	15
Mild steel	20
" " oil-hardened	25
Manganese bronze as cast	20
" " hardened by pressure	22–23

These results point to this material as the most suitable for the construction of hydraulic and other cylinders required to stand great strains, and possibly for ordnance. No. 3 quality is composed principally of copper and tin in about the same proportions as gun metal, combined with a large percentage of ferro-manganese. Its chief characteristics are great transverse strength, toughness, and hardness, the facility with which it can be cast, and the soundness and uniformity of the castings produced. It will stand melting in an ordinary reverberatory furnace without injury to the metal, which is a point of importance in producing large castings. The author is informed that a bar of this metal cast in sand in the ordinary way, 1 inch square, placed on supports 12 inches apart, requires upward of 4,200 lb. to break it, and before breaking it will bend to a right angle, and it will sustain from 1,700 to 1,800 lb. before taking a permanent set. This quality of manganese bronze is used for wheel gearing, supports and connections of machines, crank pin brasses, the shells of main and other bearings of marine and other engines, axle-boxes and other parts of locomotive engines. It is also adapted for statuary and art purposes generally, as well as for large bells.

The most important application of this quality of manganese bronze from a commercial point of view would appear to be that of screw propellers. Owing to the great strength of this quality of the metal, and its non-liability to corrosion, propeller blades can be made thinner than even those of steel. Their surfaces are very smooth, and, when cast, they are said to be theoretically true to form, whereas with steel propellers allowance has to be made against the corrosion which takes place, and their deficiency in toughness, by increasing their thickness, and their form is liable to become distorted in the annealing-oven they have to pass through after being cast. The author is informed that it has been proved conclusively by the logs of steamships which have had their steel propellers replaced by manganese-bronze blades that their speed has been increased, and the consumption of coal diminished, while the vibration and strain on the ship and machinery have been reduced. The commercial bearing of the question alluded to by the author is that these advantages are secured at a considerably less ultimate cost than by the use of steel, taking it upon the average life of a vessel; for although the first cost of a propeller with manganese bronze blades is double that of steel, it is said to be practically indestructible, whereas at the end of about three years steel blades become so corroded that they have to be renewed, which brings up the total cost of the steel blades on an average to two or three times those of manganese bronze. That these propellers are incorrodible, and in every other respect efficient, is said to be proved by experience, as some have been at work for nearly four years, and are as perfect as when first applied.

The soundness and tenacity of the No. 3 quality of manganese bronze thus applied were demonstrated by an accident which occurred to the propeller of the Garth Castle, on its launch from the yard of Messrs. John Elder & Co., in 1880. One of the blades came in contact with the jetty, and was bent round without a crack to nearly a right angle, and was afterward hammered back cold to its original form without detriment. Another example is afforded by the propeller of the North German Lloyd's steamship Mosel, which was wrecked. One of the propeller blades after it was recovered from the wreck was found to be completely doubled over, thus affording an idea of the tenacity of the metal.

With regard to the Nos. 4 and 5 qualities of manganese bronze, the author has only to observe that they have no particular claim to strength, but are effectively used for bearings, slide valves, slide blocks, piston rings, and, in fact, wherever friction occurs.

Table V. shows the results of some tensile tests applied to eleven specimens of manganese bronze. The tests in the first series were made at the Royal Gun Factories, and at University College, London, respectively. Those in the second series were made at the Royal Gun Factories, while those in the third series were made by the Manganese Bronze Company. The specimens tested at the Royal Gun Factories were 2 inches in length, while those tested at University College, and by the Company, were 8 inches in length. It is to be observed with reference to the last two samples that No. 10 was cut from the side of the ingot, while No. 11 was taken from the center. The ingot shows a higher quality on its exterior, which indicates its suitability for guns, where the interior would be bored away. The Manganese Bronze Company are, in fact, now making some castings for artillery.

Table VI. gives the results of the tests of four 8 inch samples of manganese bronze by torsion at University College. With respect to these, it is to be observed that sample No. 3 was removed from the machine unbroken, while No. 4 was broken and showed a clean shear.

Table VII. shows the results of the test of a bar of manganese bronze No. 3 by transverse strain. The bar was 1 inch square, cast in sand, and placed on supports with 12 inch bearings, a steady pressure being applied on the bar at the center.

Table VIII. shows the results of some experiments on the transverse strength and toughness of bars of manganese bronze, as compared with wrought iron and gun metal. In these tests a weight of 50 lb. was dropped from a height of 5 feet on to the middle of the bar carried on supports with 12-inch bearings. The bars were each 1 inch square and 14½ inches long. The specimens of gun metal Nos. 1, 2, and 3 were sent from the locomotive works of one of our leading railways, and were tested in the presence of an officer of the department; and the author believes they fairly represent the qualities of gun metal ordinarily found in such works and supplied by brassfounders. Nos. 4 and 5 were cast specially, and were composed of 16 parts of best selected copper and 2 parts of English tin. No. 6 was composed of 16 parts of copper and 2¾ parts of tin by weight.

DELTA METAL.

The second and latest example of the successful addition of iron to bronze is afforded by delta metal, which was brought out by Mr. Alexander Dick in 1883. And here it may be as well if the author explains how this alloy came to receive its name. He does so because it was one of the first inquiries addressed to the inventor, and because he has several times been asked the question, and if the invention had any reference to the delta of rivers. The author need hardly say that it has no such reference. The name "delta" was given to it by Mr. Dick simply for the purpose of connecting it with his own name, delta being the Greek for the letter D, the initial of the inventor's surname. In his researches and early experiments, and, in fact, in the development of delta metal into practical form, Mr. Dick was influenced by the circumstance that some twenty years since Aich and Baron Rosthorn, of Vienna, introduced a small percentage of iron into copper-zinc alloys, with the view of improving the same. The results obtained, which are tabulated by Dr. Percy in his work on Iron and Steel, show that the alloys possessed very remarkable strength and tenacity, and it seemed strange to Mr. Dick that, having such valuable qualities, they did not come into general use. A London brassfounder, who used to manufacture these alloys, informed Mr. Dick that at times he obtained excellent results with bearings and other parts of machinery made therewith, and then again the results were the very reverse, in spite of his taking the greatest care in manufacturing, as he thought, in identically the same way. Unable to account for the different result, he and several other manufacturers were obliged to abandon these alloys in spite of their promising features.

Mr. Dick endeavored to ascertain the cause of the uncertainty of these results, and he produced various quantities of the alloy, apparently in exactly the same way, by dissolving wrought iron in molten copper according to the Austrian method. The qualities of the resulting alloys, however, varied very much, simply because the amount of iron dis-

solved varied in each parcel. His first object, therefore, was to find a method by which he was enabled to introduce a known and definite quantity of iron, which he succeeded in doing by dissolving the iron in molten zinc to saturation, and adding the same, with or without pure zinc, to the molten copper. The desired quantity of iron can be introduced with great nicety. In consequence of the metals partly oxidizing during the process of remelting, the castings, however, again varied in character, the oxides being dissolved in the alloy and destroying its tenacity and strength. This second difficulty was overcome by adding a small percentage of phosphorus in combination with copper. In some cases Mr. Dick also introduces tin, manganese, or lead into the alloy, to impart special qualities to it. By a series of experiments the most useful combinations were then ascertained, and alloys of definite compositions, and possessing special and very valuable qualities, are now produced under the name of delta metal.

The specific gravity of delta metal is 8·4, its melting point 1,800°. In color it resembles gold alloyed with silver. It can be worked hot and cold. When melted, it runs freely, and the castings produced from it are sound and of a fine, close grain. Like all copper alloys, it does not weld, but can be brazed like copper or brass, and if the object is of sufficient thickness, it can be "burned" with great facility. Cast in sand, it has a breaking strain of over 21 tons per square inch. When forged at a dark red heat, the breaking strain is raised to from 33 to 35 tons, and when hammered or rolled cold it will stand a strain of more than 40 tons per square inch. The varieties destined for working cold can be drawn into tubes and wire, or rolled into sheets and rods, while those intended for working hot not only can be rolled with great facility when heated to about 1,600° Fahr., but are also capable of being stamped or punched, similarly to wrought iron and steel, into a great variety of articles which have hitherto been cast in bronze or brass. The author would draw special attention to this quality of delta metal, as the possibility of hot stamping offers great advantages over castings—the articles are turned out much cheaper, they are of perfect soundness, and possess three times the strength of brass castings. Blowholes, which frequently can only be detected after expending time and labor, are impossible; besides which a great saving is effected in the finishing of such articles, as, unlike castings, the stampings leave the die almost perfect, requiring little or no tooling, but ready to be polished. Experiments are being made at the present time to utilize the semi-plastic state of heated delta metal to press it by hydraulic pressure into tubes and rods of round, hexagonal, and other sections in a way similar to that in which lead tubes are pressed.

It is interesting to know that the iron introduced by Mr. Dick's process is really chemically combined. This is proved by the alloy not rusting when exposed to the moist atmosphere, and also by its having no influence whatever on the magnetic needle. Experiments have shown that by suspending a piece of delta metal on a thread, and at various angles between the ends of a powerful electro-magnet, no oscillations of the suspended metal could be observed, which evidently proved that the iron contained therein had lost its magnetic properties.

The uses to which delta metal can be applied are very numerous. It is said to replace the best brass and gun metal with advantage, and in many instances iron and steel also, as it does not corrode or rust. Thus parts of rifles, of guns, of torpedoes, tools for gunpowder mills, parts of bicycles, gongs, and a number of domestic articles, are now stamped in delta instead of steel; while spindles for steam and water valves, plungers, and pump-rods are forged in the same metal. In the International Exhibition at the Crystal Palace may be seen a steam launch constructed throughout of delta metal by Messrs. A. F. Yarrow & Co. This launch is 36 feet long over all, with a beam of 5 feet 6 inches, and a depth from gunwale to keel of 3 feet. Delta metal having been proved by experiment to be equal in strength, ductility, and toughness to mild steel, the plates and angle pieces of the launch are of the same scantling as they would be if steel were used, viz., $\frac{3}{16}$ inch thick. The stern, keel, and sternposts are of forged delta metal, and scraped together as is usually done. The angle frames are made of the same material, but are placed longitudinally instead of transversely, by which means greater longitudinal strength is secured. The propeller, which is cast in delta metal, is four-bladed, 2 feet 4 inches in diameter, and 3 feet pitch. The engine is of the usual direct-acting inverted type, of sufficient power to develop a speed of from 8 to 9 knots per hour. The superiority which delta metal possesses over steel and iron for shipbuilding is that it does not rust like they do. Such launches are specially adapted for the transport of salt, sugar, and chemicals, which rapidly corrode steel. The extra first cost would probably be quickly repaid, besides which the metal always retains its value.

In table IX. are given the results of some experiments made at the imperial testing-house, Berlin, on May 28 and June 4, 1884, to test the tensile, torsional, and crushing strength of delta metal. Table X. shows the result of a test of, a cast delta metal chain. From these tables it will be seen that the elastic limit of delta metal is 31,571 lb., or 14·1 tons per square inch. The commencement of permanent set took place at 49,757 lb., equal to 22·2 tons per square inch. The breaking strain per square inch was 80,658 lb., equal to 37·34 tons; the elongation was 12·9 per cent., and the contraction of area of fracture 17·4 per cent. The crushing test, with a stress of 22,000 lb., gave 0·80 per cent. of compression; 44,000 lb., 1·33 per cent.; 66,000 lb., 2·03 per cent.; 77,000 lb., 2·71 per cent.; 88,000 lb., 3·87 per cent.; 99,000 lb., 5·77 per cent.; 110,000 lb., 8·20 per cent.; 121,000 lb., 10·76 per cent.; and 132,000 lb., 13·41 per cent. The ultimate or crushing stress per square inch was 135,700 lb., equal to 60·05 tons. In the torsional tests the sample was 10 inches long, and it will be seen that it was twisted more than twice round, the torsion being registered in degrees. The chain tested (the results of which are given in table X.) was a portion of one of those supplied to the Brazilian armorclad turretship Riachuelo. The length tested was 10 feet, the links being 0·733 inch in diameter, and the length giving way under a stress equal to 19·3 tons per square inch.

TABLE X.—TEST OF CAST DELTA METAL CHAIN.

Description.	Stress.	Extension.		Remarks.
		Under stress.	Permanent.	
	Tons.	Inches.	Inch.	
Delta metal chain cast in sand—0·733 inch diameter of link, 10 feet long.	2·176	0·070	0·01	
	2·544	0·1	0·03	Appearance of fracture—yellowish gray, close, and uniform.
	2·946	0·2	0·1	
	3·381	0·3	0·25	
	3·616	0·4	0·34	
	3·870	0·5	0·43	
	4·040	0·6	0·53	
	4·285	0·7	0·62	Complete fracture at root of link (several links partly fractured).
	4·464	0·8	0·72	
	4·665	0·9	0·81	
	8·147	2·8	—	

Ultimate Stress = 19·3 tons per square inch.

PHOSPHOR COPPER.

We have now done with the modern bronzes of what the author may call the primary series, and have reached those which may be considered as forming a secondary series, in the sense that several of them are more or less but modifications, combinations, or adaptations of those previously described. The author has already referred to the beneficial effect of phosphorus on copper and its alloys, and which consists in producing a material of absolute closeness, of the highest possible degree of toughness and elasticity, or, according to the percentage of phosphorus added, the metal can be rendered soft, or as hard as steel. These excellent qualities must not be attributed alone to the phosphorus in the metal, or only in a secondary degree, but are owing chiefly to the absence of oxygen, which, by the energetic reducing action of the phosphorus, is entirely eliminated. This question having received the attention of Mr. W. G. Otto, of Darmstadt, that gentleman conceived the idea of introducing phosphorus into copper in order to facilitate the work of engineers and founders by enabling them to add a certain proportion of phosphor copper to a given bulk of metal, so as to obtain a phosphor bronze suitable for various purposes. Phosphor copper contains from 15 to 16 per cent. of phosphorus, and Mr. Otto, who is represented in England by Mr. G. Hartmann, applies this product to the purposes of producing phosphor-bronze, homogeneous copper castings, and copper alloys of all classes. In practice the copper is melted in the ordinary way as rapidly as possible, and is kept covered with charcoal. After the requisite quantity of tin, zinc, etc., has been added to the liquid metal—or if remelting old or scrap metal, after these have been completely melted—the crucible is taken out of the furnace and the metal carefully freed from the charcoal, etc., floating on the top, after which the small quantity of phosphor copper necessary is added while thoroughly stirring the metal. A skin which is found covering the liquid metal (bronzes in particular) then disappears, and the metal assumes a perfectly bright surface, which is a sign that the quantity of phosphor copper added was sufficient to remove all oxides present. The metal is then cast at once, care being taken to prevent foreign substances and any skin which may meanwhile have formed again from being poured into the moulds. The presence of a perfectly bright surface is absolutely necessary, and also careful stirring of the metal down to the bottom of the crucible, for which purpose Mr. Otto makes special stirrers. With regard to the proportions to be observed, the author is informed that for producing phosphor bronze and remelting old gun-metal an addition of from 10 to 12 oz. of phosphor copper containing 15 per cent. of phosphorus per 100 lb. of metal is generally sufficient, while for making and remelting brass and brass scrap an addition of only 5 to 7 oz. of phosphor copper is required per 100 lb. of metal. The author understands that Otto's phosphor copper is in use at many Continental government works, as well as by foreign railway companies and at private works, with every satisfaction. Without for one moment wishing to appear as questioning this, the author still adheres to the opinion already expressed, namely, that to purchase the ingots of metal for the various required purposes already prepared by those whose sole business it is to produce them, and whose credit is at stake if an error of proportion be committed, is to his mind the more satisfactory course. He conceives it to be pitting rule of thumb against careful research and practical experience.

PHOSPHOR-MANGANESE BRONZE.

There is in the market a compound known as phosphor-manganese bronze, which is stated to be used for engineering purposes. The author has twice written to the producers of this alloy for information respecting its nature and uses, but without receiving a reply to either of his letters. It is, therefore, the manufacturers' misfortune, and not the author's fault, that this production is not described in the present paper. Silence, however, is said to be golden, and, looking at the compound name of the alloy in question, the adage may apply with special force in the present instance.

PHOSPHOR-LEAD BRONZE.

About the middle of the year 1881 a new alloy under the name of phosphor-lead bronze was brought to the author's notice. It was stated to be specially adapted for all purposes where gun metal, brass, or other material is used in the construction of those portions of machinery subject to constant wear or continuous friction The introduction of lead into its composition, and its homogeneousness, were said to give it special properties, rendering it most efficacious for the purpose mentioned. It had been subjected to every test that experience could suggest, and was reported to have passed them all most satisfactorily. The advantages claimed for phosphor-lead bronze were self-lubrication, greater wearing capacity than any other metal or alloy, great tensile strength—combined with extreme hardness—and non-liability to fracture. It was averred that it remained perfectly cool under continuous and excessive friction, and it was said to be in extensive use on the Continent by manufacturing engineers, shipbuilders, and others with satisfactory results. It was being introduced into this country by Messrs. K. H. Kuhne & Co., of Lobtau, near Dresden; but the author has not heard anything further of this alloy.

PHOSPHOR TIN.

Under the name of phosphor tin, Messrs. Billington & Newton manufacture a compound which is used for making phosphor bronze. This compound is a mixture of phosphorus with tin in certain proportions, the metal being sold to consumers who make their own phosphor bronze by adding the phosphor tin to copper. The copper is melted in a crucible, and when in a fluid state the phosphor tin is added in the same way as ordinary tin. The mixture is then well stirred with an iron rod, covered with a coating of black-lead. The metal is poured just before it begins to set in the crucible, and the moulds are always to be very dry, and where 20 per cent. of phosphor tin is used, the castings are made in chills if possible. The author has applied to the manufacturers for detail particulars and tests, but he has not been favored with them. It will be seen that phosphor tin is used in the same way as the phosphor copper already referred to, and although the use of phosphor tin is stated to be attended with good results, the author can only repeat the opinion already expressed, that, considering what diverse effects a slight variation in proportions appears to bring about, it is better for most purposes to obtain the alloy ready prepared than to trust to workmen for obtaining uniform results. The author is aware that he may be met by the statement that successful results are daily obtained by workmen using these compounds. This is no doubt true so far as it goes, but it is no answer to his assertion that rule of thumb can never hope to compete with scientific exactitude. He could give instances in the metallurgy of iron and steel where rule of thumb principles held out for a long time against the advances of higher science, but to whose dictum they were in course of time compelled to bow.

ALUMINUM BRONZE.

The history of the practical manufacture of aluminum does not extend very far back into the past; in fact, its commencement dates within the limits of the present generation. The three international exhibitions which have been held in Paris since aluminum began to be worked on a commercial scale form so many landmarks of its progress. In 1855 it was met with for the first time in the Palais de l'Industrie in the form of a large bar, and was exhibited as silver produced from clay. In the exposition of 1867 it was to be seen in a more advanced stage, worked up into castings and various kinds of useful and ornamental articles. There also for the first time was seen the alloy aluminum bronze. The Paris exhibition of 1878 witnessed the maturity of the aluminum manufacture and its establishment as a current industry, having a regular demand and supply for certain purposes within the limits permitted by its somewhat high price. To France, then, is due the merit of having been the first country to carry out Wohler's process for the production of this metal on a commercial scale, and to have created the aluminum manufacture. Until recently, moreover, France appeared to be the only country in which the trade was able to prosper. The English manufactory established at Washington, near Newcastle-on-Tyne, by Messrs. Bell & Co., did not answer, and was closed some ten years ago. The German factory started at Berlin, by Messrs. Wirtz & Co., hardly lived at all, having drooped before it was well started. In France, however, the manufacture appears to have gone steadily on from the first.

The chief obstacle which has retarded the development of the manufacture of aluminum in England appears to have been the difficulty of obtaining the metal pure, the least portion of foreign matter rendering it useless for the purpose of alloy. This circumstance, coupled with its high price, has caused its use to be very limited, although the value of aluminum alloys has long been well understood. About two years since, however, Mr. James Webster perfected his invention for producing aluminum, and which is now being practically worked. It is claimed that by his process both the objections just stated are removed, the alumina being produced in a condition of great purity, without a trace of iron, and so by care in the succeeding stages the aluminum itself is free from all contamination with foreign substances. In Webster's process the source of the alumina is potash alum. This is ground to powder and mixed with pitch and gas-tar, in the proportion of eight parts of alum to one part of pitch and one part of tar. The mixture is then thrown on the bed of a reverberatory furnace and carefully heated. By this means the water only is driven off, while the sulphur and iron remain with a little carbonaceous matter in the cake. The operation requires careful attention, since, if the temperature be raised too high, burnt alum, which is unalterable, is the result. The fused mass is then removed from the furnace, and is ready for transference to the hydrate retorts. These are made of refractory fire-clay, and are vertical. They are charged from the top, while a mixture of steam and air is blown in at the bottom. At a red heat decomposition takes place, sulphuric acid and sulphur, together with iron sulphate, being carried over mechanically by the steam and condensed in cisterns at the rear. The alumina and potash remain behind as a white cake, which is drawn from the retorts, transferred to a large tank, and lixiviated with water. The liquor, which contains all the potash, is run off into a pan and evaporated, while the alumina is transferred to bags and allowed to dry.

The Webster process appears to be a simple and successful one. All the by-products are regained, the potash and sulphur are extracted, the iron is thrown down as a fast and brilliant blue, and the residual sulphuric acid is concentrated for use. The alumina thus obtained is balled with charcoal and salt, made into a chloride and reduced for metal, the aluminum obtained being perfectly pure, and containing no iron whatever. The process is being worked by the Aluminum Crown Metal Company, and the metal itself combines strength and lightness with elegance of appearance and general utility. The metal is of two kinds, white and yellow, the former being used for cutlery and other table requisites where silver and plated goods are now employed, and for every kind of metallic fittings, lamps, harness, and carriage furniture, chains, wire, and wire ropes, and, in fact, for every purpose where a non-oxidizing bright surface is a desideratum, strength also being kept in view. The yellow metal is adapted and is stated to be used for guns, screw propellers, engine bearings, tubes, and all the various details of machinery where gun metal and other alloys are now used. The metal as made is supplied in ingots to the manufacturers of the various articles indicated, who produce the finished goods for the market. It is reported to stand exceedingly well in engine bearings, and also to give perfectly satisfactory results as applied to the manufacture of screw propellers. The metal is made in five qualities,

and each quality is made either hard or soft as may be required. Samples of aluminum bronze tested by Mr. Kirkaldy have given very high results as regards tensile strength, one specimen showing an ultimate stress of 42·4 tons per square inch of original area.

SILVEROID.

This metal was introduced to public notice in the early part of the present year. It is an alloy of copper and nickel adjusted with either zinc, tin, or lead in various proportions according to the purpose for which it is intended. Beyond this, however, there is a special method of treatment at a certain point in the manufacture which is stated to be the secret of success. The result is a metal of great whiteness, brilliancy, closeness of grain, and tensile strength. It is the invention of Messrs. Henry Wiggin & Co., and is mainly intended to take the place of alloys of the brass, bronze, and gun-metal classes, in fact, of every inferior metal where color, polish, weight, and richness of luster are desirable. The author is informed that it is in use for machinery bearings and for all kinds of cocks, valves, and engine and boiler fittings.

COBALT BRONZE.

Since bringing out their silveroid, Messrs. Wiggin have developed another alloy, which is now being introduced under the name of cobalt bronze, and which is a whiter but slightly more expensive metal than silveroid. It is, perhaps, the more interesting of the two, because there is introduced into its composition small quantities of the metal cobalt. The malleability of cobalt in a pure metallic form has long been understood; but the author believes it was not until a few years ago that it was demonstrated by Messrs. Wiggin that it might be rolled into sheets, and wrought, like other metals, into articles of utility. Its high price, however, interfered with its production, and militated against its use. This fact induced Messrs. Wiggin to endeavor to compound an alloy in which the sterling qualities of this valuable metal could be fully represented, and which, at little more than the cost of ordinary German silver, might possess in a large degree all the attributes of the pure metal itself. Possessing, as it is said to do, many of the qualities and every appearance of metallic cobalt, it is manufactured in several qualities, the higher grades being preferable, on account of their suitability for casting purposes, their close, steel-like surface, their susceptibility of a high polish, as well as their hardness, toughness, and great tensile strength. Cobalt bronze is intended to be used for the same purposes as silveroid, especially in high-class fitting work.

The author has now fulfilled the promise made at the outset of his paper, which was to place before the Society a few facts concerning such modern bronze alloys as are being usefully employed for engineering purposes. He does not lay claim to any independent personal research or experiment upon the subject, such being precluded by the constant demands upon his time in other directions. He has consequently had to accept the results obtained by others, but he accepts them in perfect good faith. As they stand, they indicate the value and importance of the modern bronzes, and will serve as guides in the choice of a metal for a given purpose. The question of modern bronzes, however, is a very important one, and presents a wide field for scientific investigation and practical research. At the present time we are comparatively in the dark upon this subject, which has not received the careful attention at the hands of metallurgists that it deserves; and if the present paper only awakens attention to this fact, it will not have been written in vain. It will be seen that the author has divided the bronzes into two classes, namely, those which come under the head of original productions and those which he can only consider as imitations. In thus distinguishing them he desires to give offense to none, but he sees no way of evading what he believes to be a common-sense and equitable conclusion. In conclusion, the author will only suggest that, in selecting a material for practical use, proper regard should be had to the precise purpose the metal is required to serve, and that careful scientific preparation, based upon long experience, should be allowed to prevail against rule of thumb and a possible small saving in first cost. He would the more strongly impress this view of the case upon the members because he well knows that, although imitation is the sincerest form of flattery, flattery usually has to be paid for by some one or other.

THE DEPOSITION OF SILVER ON GLASS, ETC.*

By FRANK L. JAMES, Ph.D., M.D.

THE advantages of silver over mercurial amalgam as a material for mirrors, aside from the very important one of the health of those who are engaged in the manufacture of the articles, are many. In the first place, when carried on properly, with due attention of the recovery of waste, the silvering process is much cheaper than that of amalgam. A strong, brilliant, and lasting coating can be made, when silver is worth $1.15 per ounce, for about 3½ cents per square foot. At St. Gobain the actual cost of material and labor is figured at 36 cents per square meter. Of course, in conducting small operations we cannot hope to arrive at any such results. Another advantage which silver possesses is in point of light. Photometric experiments, instituted and conducted by Liebig, show that 96 per cent. of all light received by a properly silvered mirror is reflected, while the best results obtained with amalgam mirrors show only about 65 per cent. reflected. I quote these figures from memory after a lapse of twenty years, but I am quite sure of their correctness. Objections have been raised to the silver reflection on the ground that it has a yellowish tinge. This defect, if it be one, is easily remedied by giving the glass a slight bluish tint, which will act as a corrigerant of the offending hue. Another method of remedying it is suggested further on. Other advantages of the silvering process will suggest themselves to my readers, not the least of them being the readiness and ease with which it can be applied by every person who has a grain of manipulative skill.

Having thus cleared the way, I will now proceed to a description of methods, and will commence with that of Liebig, but before I do so I will give the process for preparing glass for silvering, as no matter what process is made use of, the success of the operation depends to a great extent upon the absolute chemical cleanness of the surface which is to receive the metal.

Make a paste of fine whiting, free from grit, or of precipitated chalk, with stronger water of ammonia, and with it cover the surface of the glass. Let it dry on, and when dry brush it off with a soft brush, clean soft cloth, or with a pledget of perpared cotton. Lay the glass in a suitable vessel (for a small mirror, a saucer will answer), and pour over it dilute nitric acid (1 part of acid to 8 parts of water). If the object has ever been silvered before, or has been coated with mercurial amalgam, the acid should be full strength instead of dilute. In this bath it should remain several minutes and then be rinsed in distilled water, which should be poured on until it comes off without an acid reaction. After rinsing with distilled water the object should be placed in absolute alcohol, and not removed thence until placed in the silvering solution.

As originally devised the formula of Liebig, while yielding most excellent results where laboratory facilities were abundant, presented certain difficulties in manipulation which prevented it from coming into general technical use. It was therefore modified, and is now as follows:

In 1 pint of distilled water dissolve 38 grains of aldehyde ammonia, and in equal quantity of distilled water 60 grains of nitrate of silver. For use mix the two solutions in equal parts, agitate and filter. The object to be silvered having been previously cleaned, is placed in a suitable vessel and covered with the filtered solution. A gentle heat is now applied by means of a water-bath or otherwise, and the temperature is raised to 120° F. Silver commences to deposit at 122°, and the operation is soon completed. Some little ingenuity may be exercised by the operator in each individual instance as to the best methods of immersing the object. If flat, it may be laid in a saucer or suspended on the surface of the fluid; if more than one object is to be silvered, and the metal is to be deposited on one side only (as is most generally the case), they may be placed face to face, and a narrow rubber band sprung around the edges.

In Germany aldehyde ammonia is an article of commerce, and may be obtained at almost any chemist's. In the United States it is not so common, but may be got from dealers in chemicals, especially from those who furnish analytical chemists their supplies of reagents, etc. Aldehyde can be obtained anywhere, and may easily be converted into aldehyde ammonia by passing a stream of dry ammonia gas through it.

Draper's method is almost as simple as Liebig's. It is as follows:

Dissolve one ounce of crystallized nitrate of silver into two ounces of pure distilled water. Add stronger water of ammonia until the brown precipitate at first formed is nearly, but not quite, redissolved. The ammonia must be added cautiously and with continued stirring toward the last, as an excess interferes with the successful precipitation of the silver. If by accident so much has been added that the brown precipitate is entirely redissolved, nitrate of silver should be added in solution until a slight precipitate is again formed. Filter and add distilled water to make six ounces. This is the silver solution. In five ounces of distilled water dissolve 336 grains of tartrate of sodium and potassium (Rochelle or Seignette salts), filter, and add water to make six ounces. This is the reducing fluid. To use, mix the solutions in equal parts and proceed as before.

Petitjean, whose method is most in vogue in France and Belgium, has substituted tartaric acid as the reducing agent. His formula is as follows:

Prepare an ammoniated silver solution the same as in Draper's method. For the reducing fluid dissolve 35 grammes of tartaric acid in the same quantity of water as before (*i. e.*, five ounces), filter, and bring up to six ounces by adding distilled water. For use, mix equal quantities of the fluids, and proceed as in former methods. At the great mirror factory of St. Gobain, two baths are used. After allowing the silver to deposit from a bath made as directed above, the mirror is treated to a second bath in which the reducing agent is double the strength of the former—seventy grains to six ounces of water.

Neither Draper's nor Petitjean's method requires so much heat as has been found valuable in Liebig's process, a temperature of 90° to 110° F. having been found all-sufficient.

Processes might be added by the half-dozen, but no valuable object would be subserved by so doing. The original process contributed by me to the *Journal of Microscopy*, and referred to at the outset of this article, is perhaps the most practical for off-hand use in the laboratory or the workshop. It has the advantage of requiring no artificial heat, of keeping for a very long time, and indeed of improving with age. It is as follows:

Silvering Solution.—In one ounce of distilled water dissolve forty-eight grains of crystallized silver nitrate. Precipitate by adding strongest water of ammonia, and continue to add ammonia drop by drop, stirring the solution with a glass rod until the precipitate is nearly, but not quite, redissolved. Filter, and add distilled water to make 12 fluid drachms.

Reducing Solution.—In one ounce of distilled water dissolve water twelve grains of Rochelle salts. Boil in a clean, long-necked flask, and while boiling add two grains of crystallized nitrate of silver previously dissolved in one drachm of distilled water. Continue the boiling for three or four minutes, remove from the lamp, let cool, filter, and add distilled water to make 12 fluid drachms.

For use, mix the two solutions in equal proportions.

SUGGESTIONS IN DECORATIVE ART.—LARGE VASE IN CHINESE CLOISONNE ENAMEL.

* Extract from a paper read at the seventh annual meeting of the American Society of Microscopy.

While a temperature of from 100° to 120° F. hastens the deposition of silver with this fluid, it is by no means necessary, as the metal will separate (though slowly) at a very low degree of temperature.

To avoid the yellow hue referred to above as one of the inherent qualities of light reflected from silver mirrors, there is in addition to the plan suggested, a way of converting the silver deposit into a true amalgam of silver and mercury, and one which is not obnoxious to the indictments brought against mercurial amalgam processes in general. I do not know by whom it was suggested, but a trial of it has convinced me of its practicability even on a large scale. If, after the mirror has been completed by any of the above processes, a weak solution of the double cyanide of mercury and potassium be rapidly brushed over the silver with a camel's hair pencil, an amalgam is instantaneously formed which adheres firmly to the glass and gives back a perfectly white reflected light.

Having given the most practical and useful of the formulæ for the deposition of silver on glass, I must say something in regard to the subsequent treatment of the mirror thus obtained.

Having secured a film of the desired thickness, the glass should be removed from the silvering fluids before they become entirely exhausted, as otherwise a process of "bleaching" sets up, and a portion of the silver is redissolved. On removing the mirror from the solution it should be stood on edge on blotting paper or a porous tile, to drain and dry. If the silvered surface is to be used as a reflecting surface directly, *i. e.*, without the intermediation of glass, as in reflectors for telescopes, it requires a little polishing, and for this reason requires to be somewhat heavier than is needed for mirrors used in the ordinary way. The process of polishing, while a very simple one, requires a deft hand and a light but firm touch. A piece of very soft and clean buckskin, entirely freed from dust by shaking and beating, should be used for the purpose. A small amount of jeweler's rouge or putty powder is placed on it, and the silvered surface should be gone over with regular, light strokes, made with a circular movement. The final rubbings should be done with a similar piece of buckskin or chamois, but without the rouge.

If the mirror is to be used in the ordinary way, nothing remains to be done except to protect the silver deposit. If a battery be handy, the best and most perfect protection is a layer of copper deposited by electrolysis. In the absence of a battery a coat of alcoholic copal varnish surmounted with a coat of red lead answers every purpose. Whatever is used should be carried well over the entire surface and edges of the silver, not only to protect it against scratches, but against the chemical action of atmosphere laden with sulphureted hydrogen, as is the case in all large cities.

The processes which I have described for the deposition of silver on glass may be applied equally well to its deposition on any chemically clean non-porous surface of organic or inorganic origin. Metals, crystals, horn, shell—in short, any surface that can be freed from adherent grease and kindred impurities may be covered with a film of pure silver by following the details of methods given for glass.

In many instances, however, the film will be imperfectly attached, will not adhere firmly, or will not deposit at certain points. Especially is this the case in porous or semi-porous substances, like wood, leather, flowers, leaves, etc. In such cases success may be obtained by the use of the following, which has been used by me for many years: Objects of leather, horn, etc., will need no preparatory treatment; but very porous substances, like unglazed earthenware, should receive one or more applications of some filling material, such as copal varnish or water glass, the former being preferable. An alcoholic solution of shellac is also good.

The object to be silvered is immersed four or five minutes in a saturated solution of gallic acid in distilled water, and thence removed into a two per cent. solution of nitrate of silver in distilled water. Here it is kept an equal length of time, and thence moved back to the gallic acid solution, the operation being repeated several times until the object assumes a silver gray appearance, due to the deposition of an exceedingly tenuous film of silver on the outer surface and in the minute pores of the object. It is now rinsed in the clear water, and laid on bibulous paper on a clean tile to dry. In the mean time prepare the following solutions:

1. *Reducing solution.*—Grape sugar or honey, 5 parts; quicklime (CaO), 2 parts; tartaric acid, 2 parts; distilled water, 650 parts. Mix, dissolve, and filter. [To those not acquainted with chemical manipulation, I would suggest the *modus operandi*, as follows: Dissolve the sugar or honey in a large part of the water, and add the quicklime. In the course of a few hours the lime will be nearly or quite dissolved. In the residue of the water dissolve the tartaric acid, and mix the two solutions. Let stand for a few hours, and then filter or decant.]

2. *Silvering solution.*—Dissolve 20 parts of nitrate of silver in 650 parts of distilled water, add stronger water of ammonia cautiously, with constant stirring, until the precipitate is nearly, but not quite, redissolved. Filter, and preserve in glass-stoppered bottles.

The reducing solution should be kept in bottles filled to the cork and tightly stoppered, to protect from the action of the atmosphere.

For use, mix equal parts of the two solutions, and, after thorough agitation, filter. The object having been prepared as directed above is removed in a gutta percha or japanned dish deep enough to allow of its complete submergence, and the mixed and filtered fluid poured over it. The dish and contents are set in the sunlight or by the fire, and, under favorable circumstances (with a bright, hot sun), decomposition of the fluid commences almost immediately, the silver precipitating and attaching itself to the prepared object with great firmness and brilliancy. The rapidity of decomposition is determined by the amount of light and heat after silvering; the object should be washed in solution of carbonate of lime, rinsed, and dried. Glass, porcelain, and earthenware articles need not undergo the preliminary treatment.

Where battery facilities are convenient, there are a number of processes for plating organic substances which may be made use of. All of them are based upon the principle of rendering the surface to be plated a good conductor of electricity. This is generally done by immersing the object to be plated in a solution of some easily reducible metallic salt, and keeping it there until more or less of the solution has absorbed into the surface pores. The absorbed salts are then decomposed by the chemical reagent, which sets them free in an extremely divided form, and, thus deposited throughout the surface structure of the object to be plated, it virtually acts like a continuous surface. From their instability in solution or ready reducibility the salts of silver are generally used. The processes resorted to in the arts in France, Germany, and Italy are Ore's and Cazeneuve's.

In the latter most excellent results are obtained, as follows: Dissolve 40 parts of crystallized nitrate of silver in 1,000 parts of wood spirit. Macerate the object in the solution until sufficient absorption has taken place. The length of time required for the result is variable, and only to be determined by experiment, the horny plates of a beetle, for instance, taking more time than the softer parts or than a piece of leather. There is no danger of leaving the object in the solution too long, or, rather, no harm can be done by an excess of material absorbed. Removing it from the bath, the object is partially dried, by allowing any excess of fluid to drain off, and is then immersed in a solution of ammonia. By this the double nitrate of silver and ammonia is formed, which is an extremely easily reducible salt. The object is now dried and suspended in a close box, in the vapor of mercury. In a few moments the surface is completely covered with a metallic amalgam, and may then be electroplated in the usual manner.

In Ore's method sulphureted hydrogen is used instead of mercurial vapor. The article, prepared by immersion in silver nitrate dissolved in methylated spirits, is put into a close box and subjected for fifteen or twenty minutes to the actions of the hydrogen sulphide. By this treatment the silver nitrate is converted into silver sulphide. After exposing the object to the air a few minutes, it is transferred to the galvanoplastic bath, and the operation completed by electrolysis. This process is especially applicable to organic material. A human brain thus prepared several years ago is still in good condition.

In conclusion I would say that I claim nothing new or original in the methods here presented. I have simply collated the results and experiments of others, and having experimented with them, place them before you in a practical form. Every formula here given has been tested and worked by me time and again, and if intelligently followed out, will always yield good results.

PROGRESS MADE IN THE IMITATION OF PRECIOUS STONES.

STRASS, a name often found coupled with that of imitation stones, was a German jeweler, who lived about the commencement of the last century. He, possessing a certain amount of chemical knowledge, hit upon the plan of utilizing the processes of making glass then in vogue, but applying them to the new object of copying precious stones. He may thus be regarded as an inventor.

Long before his time, various attempts had been made in this direction, but limited solely to the imitation of the diamond, which they tried to duplicate by using rock crystal, the pale sapphire and topaz, the yellow diamond, Rhine pebbles, etc.; but the plan of imitating the diamond by increasing the density of glass, or of copying the precious colored stones by introducing oxides and coloring matter, had never been tried.

"Strass," the principal base of other imitations, is generally composed of silica, potash, borax, and various oxides of lead, and sometimes of arsenic. Thus, chemically speaking, it may be called a double silicate of potash and lead.

Silica is found in rock crystal, in white sand, and silex. However, the first is preferable, as in these combinations one of the prime essentials is the extreme purity of the materials or ingredients used. In the manufacture of imitation stones, more important and difficult also than is generally believed, perfect success depends not only upon the selection of articles used, but also on the care exercised and the precautions that are taken. For instance, the crucibles used must be composed of proper materials, possess the power of resisting the strongest degree of heat, and must be proof against the action of metallic oxides. All substances to be melted must first be thoroughly pulverized. It must also be remembered that the most perfect mixtures can only be obtained by repeated siftings. The sieve must always be used for the same purpose, and under no circumstances employed for different ingredients. The parts, once thoroughly mixed, are melted in the crucible in a cylindrical oven. Very dry wood must be used, broken up into small pieces, to produce the heat, and this must increase gradually and equally, especially at its highest temperature. The fusion once accomplished, which takes from twenty to thirty hours, the crucible is allowed very slowly to cool.

Among those who have contributed to advance this interesting and important industry are the names of Strass, Douhaut, Wieland, Lancon, father and son, Bouguignon, Maréchal, Loysel, Bastenaire, Savary and Mosback, Bouillette and Ivelin, and Masson. Their imitations, especially of certain colors, leave nothing to be desired, but there is still room for improvement in some directions.

Imitation garnets have been obtained of almost the hardness of the real stones, the same density and brilliancy, and capable of the same degree of polish. It was almost impossible to distinguish them from nature's own product. Some of these artificial stones were such excellent counterparts that they were pronounced genuine by the most experienced lapidaries. Imitation rubies have been manufactured, hard enough to serve as pivots for the wheel-work of watches, but too small to be used for jewelry purposes.

Imitation diamonds have reached a state of perfection which is truly remarkable. The polished and carefully faceted paste throws forth its brilliancy, reflects and refracts the rays of light to such a degree that most people frankly confess their inability to distinguish between the real and the imitation. Especially is this the case at night.

The introduction of the "foil stone" has increased enormously the demand for artificial diamonds. This coating of foil, completely covering the back, greatly enhances the brilliancy of the stone, and lifts what is a second or third quality of "white stone" into a very fair artificial gem. It is a curious fact that the arrangement of the facets in the imitation stone known as the rose-cut (a hexagonal table with slanting adjoining facets) is productive of the best results, while it is seldom found in the diamond itself. Thousands of gross of these foil-backs have been used, and they are still not on the wane with the popular taste.

A later production is the "tipped-foil," in which only the point of the stone is coated. The general effect of this plan is very good, while the tip being concealed in the setting prevents the over-inquisitive from discovering the foil. The very latest, however, has the promising name of the Rainbow foil stone. It consists of a blending of two or three differently colored glasses, which produces a variegated play of hues very effective and brilliant under the gaslight.

The doublet, which at one time was very popular, is now used only to a small extent. This imitation consists of a section of real garnet cemented to a piece of glass, of a bluish, reddish, or greenish tint. The garnet forms the upper facing, and the color of the stone is determined by the paste underneath, thus furnishing an excellent imitation of the ruby, the sapphire, or the emerald. The garnet facing invests the stone with a hard surface to resist the wear and tear to which it is subjected, while the glass portion underneath is protected by the setting.

Pearls have been imitated, both the full round and the split or half-pearls. The best work in this direction is done in France, the peculiar qualities of the pearl color being well copied. A difficulty experienced with the half-pearl is that of obtaining an article hard enough to bear the "beading in" process. Recently a pearl has been put into the market possessing the durability required, but very glassy in appearance.

Cheap imitations of all the various gems are to be had in abundance, but it requires no connoisseur to discover their true nature.

THE HARDENING OF CEMENTS.

HERR FRUHLING, in a communication to one of the German technical societies, says the *Mechanical World*, makes some important comparisons between the rate of hardening of hydraulic cements and upon the nature of this process. According to this investigator, a Portland cement (which requires from twelve to fifteen hours to set) will inside of three days, have acquired a greater hardness than the far more quick setting Roman cement (which requires only from five to fifteen minutes to set). He makes the further assertion that, while the hardening process with the quick setting Roman cement continues for many months, or even years, this process with a genuine Portland is substantially completed within the first fifteen days: for the amount of increase in hardness which takes place thereafter, he affirms, is quite insignificant in comparison with the figures representing the hardening of the first fifteen days. In this statement Fruhling is not in accord with all writers on the subject, who are unanimous on the point that Portland cement continues to gain notably in hardness and tenacity for the period of a year, or even considerably longer. He discards also the generally accepted explanation that the hardening of cements depends on the formation of silicates. He considers a hardened cement to possess, both chemically and physically, the properties of a dense hydrate of lime. He bases these statements on the following facts: The natural hydrated silicates of lime do not exercise any decomposing action on solutions of ammonium salts—the chloride or sulphate for example—while, as a rule, the entire quality of lime in a cement, whether it be derived from a Portland or a Roman cement, will act upon the above named ammonium salts precisely like hydrated lime, to decompose them. He argues that in the production of a cement the rule should be followed not to endeavor to introduce the largest possible quantity of silicic acid, but the largest possible quantity of lime. If the proper limit is overstepped, so that, for instance, three or four per cent. more silicic acid is introduced than experience has shown to be sufficient, the result is not a better hardening cement, but on the contrary one that is almost worthless. The formation of a hydrate of lime, according to Fruhling, is the basis of a binding quality of the cements, and in comparison with lime he claims that silicic acid and alumina play a very subordinate *role*.

NASCENT HYDROGEN DIOXIDE AS A BLEACH.

FROM present appearances, the history of the introduction of chlorine into the bleachery is about to repeat itself in the case of hydrogen dioxide. Chlorine was first used in the form of its solution, in which the fiber or tissue to be bleached was placed. Years passed away before a solution of a salt which would yield chlorine was substituted for that of the element itself; but as soon as the substitute was introduced, its superiority was recognized, and the preference for bleaching powder (chlorinated lime) soon became general. As the continuous web of cloth is run through the bleach, and through the acid baths, the chlorine is set free on and among the fiber. Thus applied in the act of being set free, that is to say, in the nascent state, its effect is far more powerful than that of a solution of it, however concentrated, could possibly be.

Is not hydrogen dioxide, now, we believe, used in this country only in solution, destined to undergo a similar revolution in the methods of applying it as a bleach? If effective when thus used, will it not be more so when it is generated in contact with the fiber? The substance from which it is generally prepared, barium dioxide, is colorless, and it has no injurious action on the fiber. The acid or salt used to decompose the barium dioxide, and form the hydrogen dioxide, may be chosen from those which also do no damage either to animal or vegetable tissues. No obstacle, therefore seems to exist to the extended employment of a substance which *The Textile Record* hailed years ago as "the coming bleach," and which the Brothers Jacobson of Berlin have recently been experimenting upon with highly satisfactory results.

Like many other bodies valuable in tinctorial chemistry, hydrogen dioxide labors under the disadvantage of being known by several different names. Some technical journals call it hydrogen peroxide; others reverse this, and say peroxide of hydrogen; others, binoxide of hydrogen; others, again, oxygenated water; and yet others use the fancy name, or "name to sell," ozonized water. They all mean the same thing, neatly expressed by the chemical formula H_2O_2.

Manufacturers of hydrogen dioxide for industrial purposes have suffered much inconvenience and loss from its ready decomposition, when being transported; and this property of the compound led to a demand for another, which, while equally rich as a source of oxygen, would bear transportation. The barium dioxide, BaO_2, seemed to fulfill all the indications, and to it the above experimenters turned their attention.

Schoene had shown that barium dioxide in water, alone, undergoes slow decomposition, evolving oxygen. The Brothers Jacobson have demonstrated that the evolution can be increased by the addition of various salts to the water. The most favorable results were obtained with soluble alkaline silicates, sal ammoniac, alkaline borates, or the salts of the fatty acids. Chloride of magnesium and phosphate of soda act less strongly, and sulphates still less.

The proportion of the salt to the water may vary according to circumstances, but the following mixture will serve in most cases:

Barium dioxide	1 part.
Silicate of soda	1 part.
Water	100 parts.

For bleaching vegetable fiber, such as jute, cotton, paper pulp, etc., the solution should be more concentrated, while for animal fiber a larger proportion of the silicate of soda would be disadvantageous because of the alkali set free. The time required for jute and cotton cloth is from one to two days. The bleaching liquor can be used again as long as barium dioxide remains undecomposed. Materials to be bleached in this way must have been well scoured. The

silicate of soda may be first dissolved in water, and the barium dioxide then added, or the two solids may be mixed, and then dissolved together.

Whenever the nature of the objects to be bleached permits, bleaching with barium dioxide in an alkaline solution is preferable, because the hydrogen-dioxide formed is more powerfully decolorizing in an alkaline than in an acid or a neutral solution. This is probably owing to the formation of soluble alkaline dioxides, which are more easily decomposed than hydrogen dioxide itself.

For certain purposes, as the bleaching of oil, neutral solutions answer better; for example, those obtained by mixing barium dioxide with salts of magnesia.—*Textile Record.*

RENARD & KREBS'S ELECTRIC BALLOON.

THE Chalais-Meudon electric balloon was experimented with for the second time Friday, Sept. 12. We had the good fortune, my brother and I, to be notified of it in sufficient time to make it possible to be present during the preparations for, and the execution of, the great experiment. With a certain number of spectators from the surrounding country, we watched from the Meudon woods all the evolutions of the aerial ship, from its ascent to the moment it touched ground. We are now able to satisfy the curiosity of our readers by giving a few accurate data in regard to a matter that has so greatly attracted the attention of the public.

On the morning of Sept. 12 the screw balloon was stowed away in a vast shed, where, in spite of its dimensions, it was entirely protected from the inclemency of the atmosphere. At quarter past three o'clock in the afternoon a small trial balloon was sent up from the Chalais-Meudon inclosure, and was carried along quite swiftly by a northeast wind. The sky was blue, and numerous white cumuli hovered here and there in the atmosphere. On land there was an appreciable breeze, and the leaves of the trees were at times agitated by a slight wind. At five minutes before three, a carriage arrived in front of the shed, bringing the Minister of War, who was received by Captains Renard and Krebs, and shown by them their *materiel* in the interior of the shed. At twenty-five minutes past four the motor was tried, and, by looking through the windows of the shed, the helix could be seen revolving. At 4 h. 25 m. the balloon was detached from its anchorage, and its long car, held by forty men, served to carry it outside to the lawn that extends from the entrance of the shed. Messrs. Renard and Krebs stood in the center of the car, which is shaped like a long yawl boat.

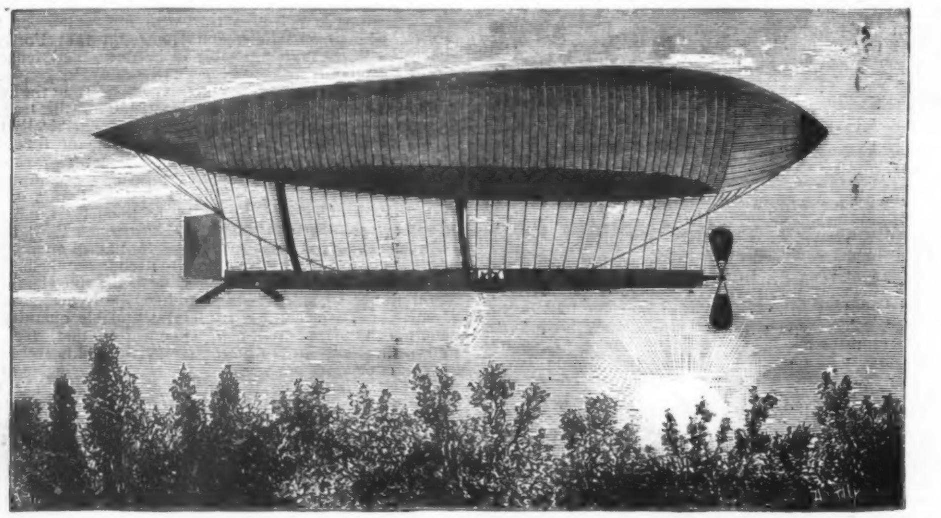


FIG. 1.—ASCENT OF RENARD & KREBS'S ELECTRIC BALLOON, SEPT. 12.

The balloon rose slowly, and preserved a perfect stability, the car remaining absolutely horizontal. The screw was at once set in motion, and the rudder was actuated in order to put the balloon about. The latter began at first to descend the aerial current, and then, under the action of its rudder, described a semicircle and sailed contrary to the wind (Fig. 1). The helix immediately revolved with a little more rapidity, but the number of revolutions did not exceed 40 per minute. The aerial ship held its head to the wind, and, for several minutes, was observed to remain absolutely stationary over some trees from which it did not appear to be more than six hundred feet distant. A maneuver of the rudder caused its axis to incline, and to thus take the wind slantingly, and it seemed as if it were about to be able to approach its starting point. Perhaps had it struggled long in this way it would have succeeded; but, after operating ten minutes, the motor, at 4 h. 55 m., through an accident, ceased to work, and the balloon was carried off by an aerial current. It was observed moving away from its starting point until a certain moment, when it descended quite rapidly, and disappeared behind a curtain of trees that hid the horizon.

My brother and I hastened through the woods and fields in the direction in which the descent seemed to have occurred, and, after a quick walk of half an hour, reached Velizy, to the west of Villacoublay, where we found the balloon, which had just effected its landing under the most favorable conditions and without any damage. The descent occurred at 5 h. 10 m., twenty-five minutes after the start. The distance passed over was, in round numbers, three miles. As the balloon had remained stationary for ten minutes, the three miles were made in fifteen minutes, thus indicating that the velocity of the wind during the experiment was about 12 miles per hour. The proper velocity of the balloon was precisely equal to that of the current in which it was sailing, since it remained immovable therein with the wind contrary.

As soon as the balloon had reached the surface a force of men from Chalais-Meudon, along with Mr. Dute Poeterin, proceeded toward the point where the landing had occurred. The screw was removed from the steel shaft and placed in the car, a group of men seized the guide-rope fixed to the front of the balloon, two men staid in the car, and the entire affair was hauled through the fields to its storage shed (Fig. 2).

The balloon, properly so called, is enveloped in a suspension covering in all parts except the lower. The front is greater in diameter than the hind part, exactly as shown in our engravings, which are from nature. The car is formed of four stiff bamboo rods connected with each other by uprights. It is about 108 feet in length and 6½ feet wide at the center. There are three small side windows near the center in order to allow the aeronauts to see the horizon and earth. This very light and elegantly shaped car is covered with Chinese silk, which is stretched over its sides. The object of this covering is to diminish the resistance of the air and facilitate the passage of the balloon through the atmosphere. The screw is in front of the balloon. It consists of two blades, and is about 23 feet in diameter. It is formed of two wooden rods connected with each other by laths curved according to a geometrical plan and covered with tightly stretched varnished silk. The car is connected with the balloon by very light suspension cords connected together by means of a longitudinal rope, which, attached toward the center, gives rigidity to the whole. The rudder, which is at the stern, is nearly rectangular. Its two surfaces, which are of silk stretched over a wooden frame, project slightly in the form of pyramids that have four faces of slight height. The aerial ship is provided with two pipes which descend into the car. One of these is designed for filling the compensating bag with air by means of a blowing apparatus stationed in the car, and the other probably serves to secure an outlet for the excess of gas produced by expansion. Behind the balloon there are fixed two oar-shaped paddles, which perhaps serve to swerve the rudder cords to the right and left. The screw is actuated by a dynamo-electric machine, and the generator of electricity is a pile on the subject of which Capt. Krebs is silent.

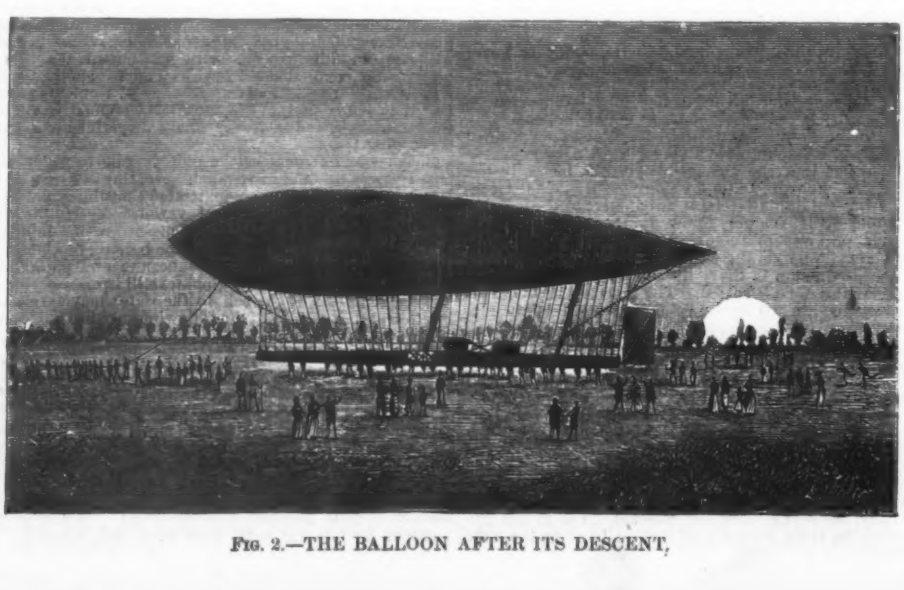


FIG. 2.—THE BALLOON AFTER ITS DESCENT.

The map shown in Fig. 3 gives the route of the second voyage made by the balloon from Chalais-Meudon. To this we add another on a smaller scale (Fig. 4) to show the distance that separates the military aeronautic establishment of Place de la Concorde, whither the aeronauts proposed to go. There is here a distance of about six miles to travel. In a subsequent experiment the learned officers of Meudon can assuredly succeed if they select calm weather, and if the generator of electricity that they use works for a sufficient length of time.

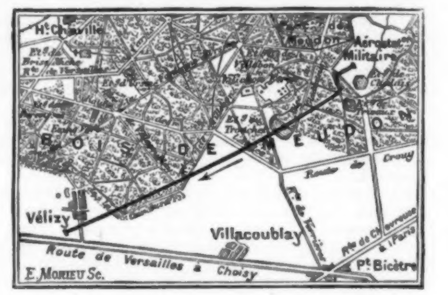


FIG. 3.—ROUTE OF THE SECOND VOYAGE.

However this may be, Captains Renard and Krebs's work may from now be considered as a great progress effected in aerial navigation by balloons.

In order that the directing of balloons may make a new progress, it is necessary that they shall be constructed of large size, so as to be able to lift motors of great power that shall assure them of a velocity greater than that of winds of medium intensity; and this is realizable with the means that the industries and modern sciences have at their disposal.—*G. Tissandier, in La Nature.*

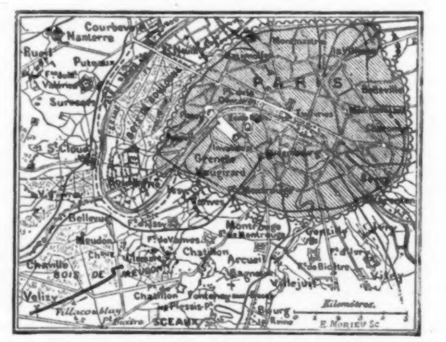


FIG. 4.—MAP SHOWING THE POSITION OF CHALAIS-MEUDON WITH RESPECT TO PARIS.

DURATION OF COLOR IMPRESSIONS ON THE RETINA.

PROF. EDWARD L. NICHOLS gives the following results of his experiments:

1. The study of the duration of color impressions produced by different portions of the spectrum confirms, in the main, the results reached by Plateau.
2. The persistence of the retinal image is a function of the wave length producing it, being greatest at the ends of the spectrum and least in the yellow.
3. It decreases as the intensity of the ray producing the image increases.
4. The relative duration of the impressions produced by the different spectral colors is not the same for all eyes.
5. The duration of the retinal image is in inverse order to the luminosity of the colors producing it.
6. Each wave length of the visible spectrum produces three primary impressions—red, green, and violet; of which green disappears most rapidly, and violet is the most persistent. Upon the different rates at which these impressions die away depend to a great extent the "subjective" tints of moving objects.
7. The duration of the retinal image depends upon the length of time during which the eye has been exposed, being very long after short exposures and approaching a definite finite minimum value as the exposure increases.

THE RELATION BETWEEN THE "WATT" AND "HORSE POWER."*

By W. H. PREECE, F.R.S.

THE most useful practical unit in use among electricians that has been derived from the C.G.S. system of absolute measurement is probably the watt, or the rate of doing work when a current of 1 ampere is maintained through a resistance of 1 ohm. The work done by an electric current is thus brought into intimate relation with all other kinds of work. The common gravitation unit rate of working is the horse power, which is 550 foot-pounds per second. The absolute C.G.S. unit is the erg per second, or the work done in 1 second in overcoming a force of 1 dyne through a distance of 1 centimeter. In any electrical measurement the electromotive force E in volts multiplied by the current C in amperes gives a product E C equivalent to so many 10^7 ergs per second, which is the watt. There are 746 watts in a horse power; and hence E C is reduced to horse power when it is divided by 746. The rate at which electrical energy is developed or expended in any part of any circuit is given in watts when we multiply the number of volts by the number of amperes. Strange mistakes are made in confusing the unit of power with the unit of work. No less an authority than Professor Adams, F.R.S., in his inaugural address as president of the Telegraph Engineers and Electricians, spoke of the watt as the unit of work.

The horse power as a unit has all the defects of an arbi-

* A paper read before the Montreal Meeting of the British Association.

trary, unscientific standard. It involves the use of coefficients; and it is not connected directly with the absolute system of measurement. It differs in different parts of the world; and its name is misleading. It could be changed both in value and name without any inconvenience except to those who are familiar with the existing coefficients and formulæ. If its value were raised 34 per cent. it would become the kilowatt, and be connected directly with the C.G S. system. It would thus become scientific, and diminish the use of coefficients. Even the present name could be retained, and its value altered from 746 to 1,000 watts, or from 33,000 to 44,233 foot-pounds per minute, without any serious inconvenience. Existing numbers expressing horse power would simply have to be multiplied by 0·746 to bring them to the value of the new unit; or numbers on the new unit would have to be multiplied by 1·34 to express their value in the old system.

I cannot help thinking that the good work of the British Association Committee will not be complete until the C.G.S. system is authoritatively applied to work and power. The following table brings together nearly, if not all, the units in common use:

Unit.	Equivalent.
Horse power....	33,000 foot-pounds per minute.
"	550 foot-pounds per second.
"	746×10^7 ergs per second.
"	7,460 megergs per second.
"	75·9 kilogrammeters per second.
"	1·01385 force de cheval.
"	746 watts.
Force de cheval..	75 kilogrammeters per second.
" ..	542·48 foot-pounds.
" ..	0·9863 horse power.
" ..	736 watts.
Watt	0·0013405 horse power.
"	10^7 ergs.
"	10 megergs.
"	$\frac{1}{9 \cdot 81}$ kilogrammeters per second.
"	0·1029 kilogrammeters per second.
B. of T. unit....	1,000 watts per hour.
C.G.S. unit	erg per second.
Megerg..........	10^6 ergs per second.
Watt	10^7 ergs per second.

According to Professor Dewar, a standard sperm candle develops 240,000 foot-pounds per hour, or 4,000 foot-pounds per minute. Now, since a watt is equivalent to 44·2 foot-pounds per minute, it follows that a standard candle develops 90 watts per minute. Again, according to the same authority, 5 cubic feet of coal gas in London develop 2,500,000 foot-pounds per hour, or 41,666 foot-pounds per minute, or 2,976 foot-pounds per candle per minute, which is equivalent to 67 watts per minute. A good glow-lamp absorbs 2·5 watts per candle per minute. Hence a glow-lamp has an economy in energy of about one-thirtieth of a gas light, and one-fortieth of a standard sperm candle. A man working very hard expends about 100 watts per minute; hence, if a man power is equal to, say, 1 standard candle, it is equal to 1·34 gas candles and to 36 electric candles! What a field for economy in lighting, and how essential it is that gas should be applied to the production of power rather than to the production of light!

EXTERNAL PARASITES OF DOMESTIC ANIMALS.

By HERBERT OSBORN.

IN considering external parasites, we must recognize that among them we have to deal with animals of very different structure and habits, some confining themselves to the hair of mammals or the feathers of birds, others sucking blood from the animal, and still others burrowing beneath the skin, causing diseases known as itch, mange, etc.; these forming groups known respectively as lice, ticks, itch mites, or mange insects, etc.

It will be noted that I do not include such insects as but temporarily depend upon animals for subsistence, such as flies, mosquitoes, and others which are certainly of very great importance to stock breeders. To consider them here would be to prolong the discussion beyond reasonable limits.

In the first place let us consider the lice, and the importance of these little creatures may be judged by the frequent discussions which have appeared, in the last two or three years, in our stock journals and farm papers, and by the many remedies that are proposed to exterminate the pests.

Their injuries are probably, however, underestimated by most stock growers, for while they may be almost constantly sapping nutritive material from their host, or rendering it restless by their irritation, it is only when they become so numerous as to greatly reduce the vitality of the animal that their presence is noted.

The species of lice are exceedingly numerous; so numerous in fact that it has been considered proper to say that every mammal and every bird has its peculiar kind of louse and some of them have three or four kinds. Still, a careful comparison shows that individuals of the same species may occur on entirely different animals, and experience has proved that they may thrive and cause serious inconvenience on other than their most common hosts.

It seems to me of no small importance therefore to distinguish carefully the different species, and determine as fully as possible just what animals it is possible for them to thrive upon. When this is accomplished, we can tell what animals it is safe to allow to associate together.

It is well known that the lice from poultry cannot survive upon the body of a man, and can cause at the most but a few hours' inconvenience. On the other hand, it is asserted by good authorities that lice from poultry kept near horses may migrate to those animals and cause serious disease among them.

The various undomesticated animals which may sometimes associate themselves with domestic species also need attention, since it is not at all impossible that they may introduce parasites in a herd which has previously been entirely free. With these points in view I feel fully warranted in believing that I can do no greater service to the stock interest of our State than to give as fully as time allows the distinctions that separate the various species, and as carefully as can be with our present knowledge, the different animals which it is possible for a single species to inhabit.

The precautions which can then be adopted, together with the remedial agencies which must be resorted to when infection already exists, may furnish valuable relief.

The lice may be separated for convenience into two principal groups, according to their structure and habits, based upon their method of procuring food. First, those which obtain their food by suction, being provided with tube-like mouth parts which are thrust into the tissues of the animal to imbibe the fluid; or, second, those which bite and chew the hair, feathers, or epidermal scales, being provided with strong jaws for this purpose. The former kind are found only on mammals, the latter on both mammals and birds.

The eggs are deposited upon the hair or feathers of the animals they infest, and are commonly known as "nits." They are fastened with a glue-like substance, and adhere rigidly to their support. The louse escapes by pushing up a lid from the free end of the egg. The exact length of time between their deposition and hatching cannot be stated, and probably differs some with the season of the year. It is probably not more than three or four days at the most. The young lice resemble the adults except in proportions, and sometimes in the markings; they grow rapidly, and probably reach maturity and begin depositing eggs in from three to six weeks. Each adult, if we may judge of different species by the one which was determined by Leewenhoek, is capable of laying about one hundred eggs. If we have a new generation every month or six weeks, the rapidity of multiplication is sufficient to account for any suddenness of appearance, which is observed in herds thought to be free from them. Apparently, reproduction is continued through the year, usually individuals of all stages, and eggs, being found together at any time of the year, but probably reproduction proceeds more rapidly during summer than winter.

LOUSE OF THE HOG.—(*Haematopinus suis.*)

This species is dark reddish brown, the abdomen gray or ashy yellow, flat and membranous, with a black horny excrescence surrounding each spiracle, which is white; the legs are long and thick, the femur is banded, and the tibia club-shaped and dark at apex. It is found sometimes in great abundance on swine, and the affected animals become exceedingly thin, and fail to grow. It is not known to occur on any other animal, and is more easily destroyed than species that occur on animals having thicker hair.

LOUSE OF THE ASS.—(*Haematopinus asini.*)

Reddish brown, abdomen large, light tawny yellow-white, with horny excrescences on each side surrounding the spiracles, head very long, with deep depressions behind the antennæ. Common on the ass, frequenting mane and back, and it also occurs upon the horse, hence care should be taken not to allow their communication from one to the other of these animals.

LOUSE OF THE OX.—(*Haematopinus eurystomus.*)

This common species is chestnut colored and shining, the head is nearly triangular in shape, being rather pointed in front, where it terminates in the back. The thorax is broad and nearly square, being slightly wider and nearly square behind, with the angles somewhat acute. The abdomen is very large, ovate in form, of an ashy white color with a row of dark plates surrounding the spiracles and a row of three to five dark plates each side of the back. It is very common on cattle, especially on the upper part of the neck and shoulders, and these parts are very frequently laid bare by the rubbing of the animal in its attempts to rid itself of the irritation caused by their presence. It is said to occur also on the horse, but I think not commonly.

LOUSE OF THE DOG.—(*Haematopinus piliferus.*)

In this species the head is of a brick red color, while the abdomen is of a flesh color and thickly covered with pale brown hairs and minute warty prominences. It occurs upon the dog, and has also been taken from the ferret. It seems to be of less frequent occurrence and less troublesome to dogs than either fleas or ticks.

THE BITING LICE.—(MALLOPHAGA.)

* *Infesting Birds.*

LOUSE OF THE PIGEON.—(*Goniocotes compar.*)

Distinguished from other lice infesting pigeons by the white abdomen, which is broad and obovate, with a reddish brown margin. This with another species mentioned later is common on all domestic pigeons.

LOUSE OF THE CHICKEN.—(*Goniocotes hologaster.*)

In this species the head, thorax, and legs are pale yellow, with pitchy black margins and spots. The abdomen is marked with pale ashy bands at the sides bordered with black. It occurs on common domestic fowls, but is by no means so common as other species.

LOUSE OF THE TURKEY.—(*Goniodes stylifer.*)

A species having the body of a bright chestnut yellow and shining. The abdomen is pale yellow white. It is said to be a common pest of the turkey, but I have not run across it as yet.

LOUSE OF THE CHICKEN.—(*Lipeurus variabilis.*)

With this species the body is elongated, of a dirty white color, and smooth and shining. The margins of the body are black. It is not known to occur on other than chicken, and in them is confined to the wing feathers as a rule.

LOUSE OF THE TURKEY.—(*Lipeurus polytrapezius.*)

This is a large and elongated species, having a pale yellowish white color, and with a black margin around the body. The abdomen is long, and all the segments but the last are marked with a grayish brown trapezoidal spot on each side.

This species is common on the turkey, and does not appear to infest any other fowl.

LOUSE OF THE DUCK.—(*Lipeurus squalidus.*)

Another species with long slender body, and of large size as compared with most of these parasites. The head, thorax, and legs are of a pale ocher color, the abdomen is dull white, and along the margin is a row of pitchy black quadrangular patches.

A very common species on ducks of different kinds, both domesticated and wild.

LOUSE OF THE PIGEON.—(*Lipeurus baculus.*)

This species is remarkably long and slender, the head and thorax are bright chestnut and the abdomen is dull, with a series of large trapezoidal brown patches on each side.

They are very common and very plenty upon domestic pigeons, but do not become distributed from them to other fowls.

LOUSE OF THE CHICKEN.—(*Menopon pallidum.*)

The feet in this species differ quite markedly from those of any of the species mentioned previously, being fitted for running rather than for clasping. The body is long and rather slender, of a pale straw color, and smooth and shining. The head is slightly excavated on each side with blackish spots.

This is the most common species on poultry, and will be found on almost every fowl examined. They run rapidly, and frequently travel upon the hands and bodies of persons that pluck fowl without previously scalding them, but they cause only temporary annoyance, and soon disappear entirely. They also infest the roosts and the timber of the chicken house, which consequently should be well whitewashed occasionally or sprinkled thoroughly with kerosene.

It is this species probably which is credited with causing such serious trouble to horses when they become infested with it, but which a little care can so readily prevent.

** *Infesting Mammals.*

LOUSE OF THE HORSE.—(*Trichodectes equi.*)

This species is a rather trim looking louse, and entirely different from the suctorial form in appearance as well as in habits; the head, thorax, and legs are of a bright chestnut color; the head is large, broad, and somewhat square, but rounded in front; the abdomen is pale yellowish covered with fine hair, and with dark hairs and with dark bands running across the central portion. It is quite common on horses, mules, and asses, said to be more so when they are fresh from pasture. But upon animals that are neglected they multiply so as to become very troublesome toward spring, and the effects of their presence sometimes become very apparent in the condition of the animals.

LOUSE OF CATTLE.—(*Trichodectes scalaris.*)

This species very closely resembles the preceding, and would not readily be distinguished by a casual observer. It is, however, shorter, the body does not taper so much toward the hinder portion, and the cross bands are rather more sharply marked. The head and thorax are reddish brown, the abdomen pale tawny in color, and the first six segments of the abdomen have a reddish brown band on the forward half. It is very common on cattle, possibly more abundant on calves, and is also said to have been taken from asses.

LOUSE OF THE SHEEP.—(*Trichodectes sphaerocephalus.*)

The head is nearly round; head and thorax rust red. Occurs on sheep, and is not known to infest any other animal. Fortunately it is not abundant, since the thick wool of sheep renders it very difficult to apply remedies except at the time of clipping.

LOUSE OF THE DOG.—(*Trichodectes latus.*)

Pale brownish in color; the head and thorax rusty yellow; the abdomen oval. It is common on dogs, especially on puppies, and is not known to infest any other animal.

LOUSE OF THE CAT.—(*Trichodectes subrostratus.*)

This species is not common and is not known to migrate to other animals. I have not, as yet, succeeded in securing specimens.

TICKS.

The parasites which are commonly referred to by this name include species which are widely different in structure and character.

THE SHEEP TICK (*Melophagus ovinus*) is an insect related to the flies, and belongs to a group which includes besides this species a number of others known as bird ticks. These latter are provided with wings, but the sheep tick is wingless. It fastens its beak-like mouth parts into the skin of the sheep, and sucks its nourishment at its own leisure. Its method of reproduction is peculiar in that the young are retained within the body of the parent until they reach the chrysalis stage, when they are discharged. Each female produces but one or two young. This insect is sometimes quite troublesome, and care should be taken when the sheep are sheared that those adhering to the body are removed or destroyed.

THE CATTLE TICK (*Ixodes bovis*) is more nearly like the spider in its structure, and is nearly related to the mite, in fact it may be considered a mite of gigantic size. It has eight legs when fully developed, and in many other respects is different from the sheep tick previously mentioned. It appears to feed indifferently upon a great variety of animals, while its natural habitation is upon plants. It attaches itself to animals as they brush by its lurking place, and then retains its position, gorging itself with blood and causing serious annoyance to its victim. Full grown individuals measure from a quarter to a half inch in length.

ITCH MITES.

These minute parasites, smaller than any we have yet considered, are perhaps of even greater importance. They are known by various names, such as mange insects, acari, itch mites, etc.

THE ITCH MITE OF MAN (*Sarcoptes scabiei*) must be considered in this connection, since it is readily communicated to various domestic animals, and causes most serious difficulty to them. It is said lions are sometimes attacked by it, and that they succumb rapidly to the disease, dying in a few months. The mite appears to the naked eye as a minute whitish speck. When magnified it is seen to be bristly and strongly marked with transverse lines. There are six strong bristles or thorns on the forward part of the body, and fourteen on the abdomen or hinder portion. It burrows into the skin, forming irregular tunnels and depositing eggs along its course. The skin presents a peculiar scaliness from these underminings, and small vesicles or pustules are formed, especially at the entrance of the burrows. When infesting horses, cattle, swine, sheep, dogs, or cats, it produces the greatest irritation to the poor creatures, who know not how to relieve themselves, and unless assisted must quickly become a prey to the rapidly multiplying pests. From these animals also the disease is likely to be communicated to every person that comes in contact with them.

THE ITCH MITE OF THE CAT (*Sarcoptes cati*) is considerably smaller than the previous species and is not so generally distributed among animals, though it is known to infest also the rabbit. It attacks particularly the head, and especially the base of the nose, the lips, the ears, and eyes, and unless quick relief is given produces a most loathsome disease, from which the animal soon dies.

THE ITCH MITE OF FOWLS (*Sarcoptes mutans*) is a very flat, broad species, and is remarkable for the suddenness with which the disease it produces makes its appearance. From fowls it may be communicated both to man and to horses.

THE ITCH MITE OF HORSES (*Psoroptes equi*).—This itch mite does not burrow into the skin of its victim, but is provided with lance-like jaws, which it thrusts into the tissues and obtains its food by suction. It is said to occur most frequently on horses and sheep, but occasionally also on cattle.

"On sheep, it is said by Mr. Delafond to give rise to 'black muzzle.' The sheep attacked has the skin of the face, lips, around the eyes, and the external surface of the

ears covered with a great quantity of furrows and mangy papillæ forming thick, hard, adherent, grayish crusts under which the mites live and breed, and the fleece falls off in great flakes." [Murray.]

THE ITCH MITE OF CATTLE (*Symbiotes bovis*) infests horses and goats as well as cattle. On the horse it is said to make its attack at first about the pasterns. Among goats it is said to cause great havoc, many animals dying from its effects.

PREVENTIVE MEASURES.

Frequently a little care in advance may prevent a herd of animals from becoming infested with lice or mites; the expense of such precaution being much less than that of applying remedies after the parasites have secured a foothold.

Where it can be done, it is far better not to allow different animals which have the same kind of parasites to associate together. In the fall of the year it is well to examine animals carefully, as during the summer pasturing the parasites have probably greatly increased in numbers, though the vigor of the animal may not have allowed them to get the mastery, but a few weeks in the stall will make their presence quite manifest. If the animals are examined when taken from pasture, those which are infested may be separated from the others to prevent distribution, and remedies can be applied when the weather is favorable. Always when a new animal is brought into the herd it should be examined suspiciously; and if there is any doubt about its being free from parasites, it should not be allowed to associate with other animals till time enough has passed to give certainty, or till applications have been made to destroy any parasites that may possibly be present.

MEANS OF DESTROYING.

While there are a few substances which doubtless are the best to apply, the different circumstances which may arise at different times and places make a choice of remedies valuable, and I therefore enumerate several, with methods of application.

Tobacco.—Steep tobacco leaves or stems, forming a strong solution, with which wash the animals thoroughly, repeating the operation at the end of the week.

Kerosene.—This is a most active agent in destroying all kinds of insect life, and the only question in its use is as to the most available method. Professor Lintner recommends applying the oil in a small quantity to a card, and occasionally carding the animals with it. He says its use in this way for a few days will prove effectual. The danger in this method is that some few of the lice or nits may not be touched, and survive to restock the animal. It may be mixed with lard or fish oil and applied by rubbing it in with a rag, care being taken not to apply too much in a place, or it may cause the hair to come out. It may be rendered perhaps still more effective by additions of sulphur. The kerosene is so penetrating that it may be relied upon to destroy the nits also, hence one thorough application will suffice; applied to the wall, ceilings, and roosts of henneries with a sprinkler or force pump, it will effectually destroy all lice and nits, and it may even be applied to the chickens themselves, care being taken that it does not reach the eyes, nostrils, or mouth.

Sulphur in almost any form is a deadly poison to lice and nits. Some stockmen go so far in use as to feed it with salt, and assert that its affect is sufficient to drive all vermin from the skin, but I much question the safety of its use in this manner, as it seems to me that a quantity sufficient to so impregnate the system as to affect the lice would surely be injurious to the animal, and while possibly affecting the suctorial species I can hardly imagine it would have any effect upon the other forms. It may be mixed with lard or tallow and applied as an ointment. It seems to me that thorough fumigation with this substance would be the most effectual and cheapest remedy. Mr. Charles Aldrich recommends covering the animal with a blanket, and blowing tobacco smoke under it and through the hair with a bee smoker. The same method with sulphur would perhaps be more effectual, but evidently it would be difficult to reach all parts of the animal with a certainty in this manner; to be most effective the blanket would need to be supported so as not to fit too closely over the back. It should reach and lie up on the floor all around, while the animal's nose, mouth, and eyes should be left uncovered. The sulphur can be rolled up in rags, and the fumes puffed out of a bee smoker, or a small quantity of sulphur may be burned in a dish with a teaspoonful of alcohol. It seems to me that for any person having a number of animals it would pay to construct a tight box-stall just large enough to easily accommodate the larger animals, with an opening at one end fitted with thick canvas to fasten around the head, back of the eyes, and with a tight door at the other end to close after the animal, the dish of the burning sulphur to be set in where the animal cannot step in it, or the fumes introduced at an opening for the purpose. A few minutes of this fumigating would kill every louse on the animal. The exact length of time which is sufficient could be determined by a few trials. To make sure that none which hatch from eggs afterward survive, the operation should be repeated in from five to eight days.

Carbolic Acid.—"A correspondent of the *Country Gentleman* (vol, 38, p. 186) commends it very highly for removing vermin from animals. He used it in the form of carbolic soap prepared by James Buchan & Co., of New York, and by simply washing the hair of the cattle with the lather from the soap, he was able to kill the vermin and the eggs with which they were infested. It also killed those on hogs." (Lintner, 1st. An. Rep. State Entom. N. Y. P. 48.)

Sulphuret of Potassium.—A remedy which is highly recommended by Professor Verrill, and judging from its composition one which might be very effective. Two to four ounces of the substance dissolved in a gallon of cold water, and applied as a wash, is said to be equally good for lice, mites, and other parasites of both man and domestic animals.

Ashes and Road Dust.—It is quite certain that fowls protect themselves very considerably from vermin by their frequent dustings, and if better means cannot be readily obtained, sprinkling ashes or fine dust on the backs of the cattle will doubtless do much to mitigate the nuisance.

For sheep infested with ticks the following washes are given by Professor Lintner: Tobacco, 16 pounds; oil of tar, 3 pints; soda ash, 20 pounds; soft soap, 4 pounds. (Sufficient for a flock of fifty.)—*Bulletin of the Iowa Agricultural College.*

A NEW ALCOHOL EXTRACTED FROM BIRD-LIME.—The new compound, ilicic alcohol, has the composition $C_{[illegible]}H_{44}O_{2}$. It is insoluble in cold water, slightly soluble in dilute ethylic alcohol, soluble in almost all proportions in ethylic alcohol at 90 per cent., fuses at 175°, and boils at 350°.—*J. Personne.*

EUGENE BOURDON.

IN 1817 there was in one of the classes of Bourbon College, at Paris, a little student who was as yet but nine years of age, and who made himself remarked by his comrades, and even by his professors, through his extraordinary aptitude for mechanics. He constructed without any one's aid all sorts of delicate and ingenious apparatus. One day, especially, to the great admiration of every one, he produced a little reel which served him for winding off silk from the cocoons of silkworms that he had himself reared. The machine, which consisted of open bobbins and transmitting gear wheels, was a true marvel of happy conception and manual skill. This apparatus, which seems so wonderful when we reflect upon the age of the one who constructed it, still exists in a perfect state of preservation in the gallery of its inventor's collections. The pupil, after the invention of this reel, soon constructed a lathe at home that served to shape all his tools.

This child, who assuredly had a genius for mechanics, was named Eugene Bourdon, and was born at Paris, April 8, 1808. His father, who was a merchant, wished to devote his son to a commercial career, and so, after his studies were ended, sent him to Germany for two years in order to learn the language. Eugene staid at Nuremberg from the age of 18 to that of 20 years. When he returned to France he obeyed the will of his parents, and entered a silk-house as an employe; but, as soon as his father died, he manifested a desire to devote himself to mechanics

In 1830 he worked for Mr. Jecker, an optician. In 1832, after being attached, as a volunteer, to the house of Calla, Senior, he established himself on his own account at No. 12 Rue Vendome, and went at his business with remarkable energy and perseverance. 'In 1833 he presented to the Societe d'Encouragement a model of a cylinder steam engine of glass which obtained a siver medal for him. From 1833 to 1835 he constructed a most varied series of models of engines designed for demonstration by professors. At the present time specimens of these ingenious models are to be found in most of the collections of educational establishments; and some of them were sent as far as to America.

EUGENE BOURDON.

Bourdon began his career without any pecuniary resources, but he had now acquired a certain fame and had saved some money. In 1835 he founded an establishment for mechanical construction at No. 74 Faubourg du Temple, where he installed himself under a modest rent of 1,200 francs. This house, of which he was then a tenant, he afterward purchased, along with the neighboring buildings, and, thanks to the efforts of his work and the fruits of his inventions, became owner of more than 3,000 meters of land in this populous quarter. The worker's perseverance was rewarded by prosperity.

Bourdon had undertaken a heavy charge, for a young man, in founding this establishment; but he multiplied his forces, and thenceforth entered into the active and militant phase of his creations. In 1837 he married, and had the fortune to be seconded in his labors by the worthy companion whom he had chosen, and who was to close his eyes on his death-bed. He at first occupied himself with a boat provided with a boiler with removable furnace. He constructed a large number of machine tools and steam-engines of large dimensions. In 1839 he brought out one of the first locomotives that had until then been built, and, soon after, he presented to mechanics an ingenious water level indicator. Finally, on the 17th of July, 1849, he took out a patent for the metallic tube pressure-gauge and barometer, which figured at the Exhibition of that year, and which were awarded a large gold medal. These new apparatus obtained considerable success at the London Exhibition of 1851, and it was at that epoch that their inventor was named chevalier of the Legion of Honor.

The invention of the metallic tube pressure-gauge, one of the most remarkable and useful inventions in modern mechanics, occurred under peculiar circumstances, that merit description.

Bourdon had built an engine for competition before the Societe d'Encouragement. At the moment of making a trial of it, his foreman came to him in great consternation to say to him that a leaden worm that formed part of the condenser had become dented and injured by an accident. There was no time to make another one. As Bourdon desired, at any price and in all haste, to remedy the accident, the idea occurred to him to put the leaden tube in a proper state by compressing it internally with water under a very strong pressure. The experiment was at once tried, and the inventor, not without surprise, saw the tube gradually straighten out in measure as the pressure increased. The Bourdon flexible tubes were created.

It would require the writing of an entire treatise upon mechanics to enumerate the work of Eugene Bourdon. After the construction of the pressure-gauge, which contributed to make his fortune, a multitude of other inventions or important improvements were devised by him, and succeeded one another from year to year during his long career. He constructed steam engines with variable expansion and external cam, machine-tools, safety-apparatus for boilers, apparatus for raising water, and pneumatic machines and pumps of various models. He invented a rotary dynamometer, a parachute lift, pillow-blocks with a reservoir of oil for continuous lubrication, a printing telegraph, etc.

In 1872, after being a constructing engineer for forty years, Bourdon confided the care of directing his house to his eldest son, and resolved then to devote himself with more ardor than ever to his personal work. From 1872 to 1884, that is to say, for fourteen consecutive years, he, so to speak, began a new career. Having become wealthy, he devoted his fortune largely to researches and experiments. At his residence in Faubourg du Temple, he set up a mechanical establishment worthy of a worker like him. Here he had improved lathes and machines of all sorts, with a motive power at his disposal. His little work cabinet, in the center of his numerous shops, became a great gallery of collections in which were assembled specimens of his constructions and all the curiosities of modern mechanics. One must have visited this sanctuary of mechanics in order to comprehend the interest and importance of it, and especially to have been shown all this by the venerated master, who explained each apparatus with wonderful clearness and great obligingness.

During these fourteen years Bourdon constructed a large number of new apparatus, and made a series of inventions. He constructed clocks according to a new system, and an entire new series of meteorological registering apparatus, and finally invented a pneumatic clock and a large multiplying anemometer. This latter is daily operating at the Paris Observatory, as well as in mines and at meteorological stations.

Up to the end of his life Bourdon preserved all his intelligence, all his strength, and his incomparable dexterity. He knew how to work glass by the lamp as well as the most skillful glass blower, and he used the lathe and all tools like a professional. He loved to encourage young workers, and his generosity was inexhaustible, his purse being always open to those who were undertaking useful experiments.

At the age of sixty-seven he was full of vigor and activity, and at the Congress of Blois took part, like a young man, in all the excursions, On his return to Paris he made preparations for terminating some experiments that he had been making for several months to determine the exact influence of speed upon railway trains. With this end in view some apparatus had been set up in a car put at his disposal by the Orleans Railway Company. But these experiments were to cost him his life, under the most painful and dramatic circumstances. After making his preparations, on the 29th of September, while attempting to get out of the car he missed his hold and fell between the tracks. He received a wound in the forehead, over the left eye, and contusions in the knees and wrists. A physician at once took him in charge, and he was afterward taken home accompanied by the engineer who had organized the experiments with him. His senses soon returned to him, and he attributed his fall to a momentary dizziness. Cerebral congestion, however, soon supervened, and he passed away surrounded by his family.

The number of those who wept over Bourdon was great, and thousands of tearful assistants took part in his funeral.

At the time of his obsequies there were exhibited, as customary, the honorary badges of the deceased. Upon seeing lying on a velvet cushion the modest cross of the Legion of Honor, which the mechanic had so well earned thirty years before, we could not help thinking how very humble such a reward was for the services rendered by this fertile inventor.

Bourdon merited more homage and more celebrity, but he was exceedingly modest, and sought neither distinction nor honor.

A man of work and activity, he never knew rest. It will be seen that, despite his white hair, he died at the breach upon the battle-field of scientific experiments.—*La Nature.*

MEMOIR OF ROBERT B. TOLLES.

By DR. GEO. E. BLACKHAM.

"HE was a man of very retiring disposition, making the obtaining of the facts for the memoir exceedingly difficult. A sister of the deceased, now living in Chicago, had been found to be the principal source of information concerning the life of Mr. Tolles. It was a touching narrative of genius struggling with poverty and ill health, and ultimate success.

He was born at Winchester, Litchfield County, Connecticut, and was the second of five children. His early days were spent on the farm and his early education was very much neglected. At the age of 18 he suffered from a very severe attack of pleurisy, from which he never recovered. His father was an inventor who died in Cincinnati in 1848. His mother died in 1841, soon after which he walked to the house of an uncle living near Rochester. On the way home he stopped at Canastota, and became an apprentice to Mr. Spencer. In 1858 he established a place for himself in a loft. In 1867 he became superintendent of the Boston Optical Works, and later the whole management of the works was placed in his hands. In 1873 he made a step which placed him at the head of his profession by inventing a three-system lens. He invented many other improvements which did more for microscopy than the inventions of any other man at the time.

He was tall, thin, and slight, with long, full beard and brown hair. He was painfully shy and reserved. His life was a long struggle with poverty and disease, but he had an indomitable will that kept him in the workshop, where he was content to remain so long as he could do good work. During his last illness he had a microscope brought to his death-bed, where he made examinations of lenses. He could get rest only by sitting in a chair, for many years. He died November 17, 1883, at Boston, where he had worn himself out with work and devotion to his business. His funeral was largely attended by scientific friends, and his body lies in the beautiful Mt. Auburn Cemetery. His brother-in-law will erect a monument, but the most enduring monument to his genius are the splendid lenses he has left as the result of his genius and untiring ambition. To great theoretical and practical knowledge of the science of optics he united mechanical and inventive genius and marvelous skill of eye and hand.

While still in the service of Mr. Spencer he devised the form of cover correction for objectives, in which back and middle combinations have a rectilinear motion only, and the front remains entirely stationary. In 1853 he invented and patented his solid eye piece. In 1858 he made his first immersion objectives, though of course this plan was not original with him. In 1858 he constructed objectives with two fronts, one to be as an immersion and the other dry. In August, 1873, he made the great step forward which

placed him at the head of his profession, the Columbus of a new era of microscopy. He made an immersion one-tenth with an aperture greater than that corresponding to infinitely near 180 degrees in air. It was a three-system lens, and had an aperature of more than 110 degrees in balsam or 1 25 N. A. The same month be made his first lens of the duplex front formula one-fifth glycerine immersion of 110 degrees balsam angle. Both passed into the possession of the Army Medical Museum at Washington, and both were practically homogeneous immersion lenses, as they gave the very best results when immersed in soft balsam, which had been brought as nearly as possible to the same index of refraction as the crown glass of which their front lenses were made viz., 1·525. The importance of this bold step and its influence upon the progress of microscopy can scarcely be estimated at this time, but it is certain that it was the cause of a revolution of opinion and practice among users and makers of microscopes all over the world.

Mr. Tolles was the inventor of many other devices and appliances for the microscope. In 1866 he invented and patented his stereoscopic binocular eye piece; in 1878 he received two patents for improvements in the microscope stand. For years his stands were models of elegance, convenience, and stability, and his mechanical stages are, I believe, unequaled to-day for delicacy of construction and perfection of working. In addition to his work on the microscope he made some telescopes remarkable for their short focal length in proportion to the diameter of object glass, and for their remarkable defining and penetrating power, a small instrument with an objective only one inch in diameter, easily carried in the pocket, being fully equal to a good instrument of two and a half inch objective and three feet focus.

WORK OF THE HYDROGRAPHIC OFFICE.

THE work of the United States Hydrographic Office, made more prominent lately by the establishment of Branch Offices in the Maritime Exchanges of the principal sea-board cities, has just been outlined by the Hydrographer, Commander J. R. Bartlett, U. S. Navy, in his annual report. The Office had not been able to extend the full benefit of its co-operation to the Merchant Marine, owing to its remoteness from the class of people it was intended to benefit, and to the natural hesitation of the latter to take advantage of its resources. Naval officers were sent, therefore, to establish Branches in Boston, New York, Philadelphia, Baltimore, New Orleans, and San Francisco, to bring the main office into closer relations with sea-faring men, the liberality of the Maritime Exchanges of these cities providing rooms for the purpose.

It should be remembered that the naval officers and the outfit of hydrographic publications of these Branches are entirely at the service of the community without cost, while all money transactions of the Hydrographic Office are conducted by specially appointed civilian agents to be found in all sea-board cities.

The six Branch offices have more than realized all that was expected, and the most gratifying assurances of their increasing value are continually received from all interested, either directly or indirectly, in the sea-faring public. The following summary is presented of some of the advantages that have already accrued to the Merchant Marine:

It has been found, in response to the invitations to all ship captains to bring their charts for verification and correction, that many use old editions (in one instance 50 years old), and they have been surprised to find that new editions showing quite different hydrographic conditions have long since supplanted them.

The Notices to Mariners, which had failed to reach the class most interested, have been most thoroughly disseminated, and their usefulness demonstrated, so that the demand for them has been greatly increased.

The number of official correspondents, including Hydrographic Offices, Light-house Boards, Colonial and Port Departments, has been increased.

From these 2,400 printed Notices in ten different languages have been received, all of which have been translated by officers. From this and other sources 387 Notices to Mariners, containing 1,070 announcements, were issued, and 310,000 copies were distributed gratuitously all over the world.

The Pilot Chart of the North Atlantic Ocean through the same channel has obtained a still wider circulation.

The reception of this graphic bulletin of what has occurred on the sea during the month past, and what may reasonably be expected during the coming month, has been most flattering. The demand for it among sea-faring men has steadily increased as it has become more widely known, and the interest it has awakened among ship-masters is indicated by the fact that several have telegraphed from Europe at their own expense any interesting information they may have encountered during the voyage across.

The drift of the various derelicts has been especially interesting as showing the general set and velocity of the principal ocean currents. The publication of the position of these floating wrecks undoubtedly has been the means of guarding against collision with them. It has been known that vessels have taken the safe route indicated during the prevalence of icebergs, when they would otherwise have taken a more dangerous course. The publication of this chart has also facilitated the study of the limits of the trade winds, the general location of water spouts, and will be the means of defining eventually the approximate limits of fogs off the coast of the United States and banks of Newfoundland. The sailing routes laid down have been followed with satisfactory results.

The importance of a central office which gathers this information having been thus practically shown, as was expected, the voluntary contribution of information has been largely increased. The interest of ship captains has been aroused under the stimulus of an immediate and practical acknowledgment of their work to make such examinations as they can of reported dangers of all kinds, to call attention to inaccuracies in the charts, and to report immediately and definitely all new matters relating to hydrography and cartography which come under their observation. Many ship-masters go to the branch offices for information in regard to the prices of the publications of the Hydrographic Office, and in numberless instances it has been found that they have been in the habit of paying more than the price authorized by the catalogue. This often deters them from buying late additions, to the manifest injury of their owners and to the prejudice of the office. The doing away of this abuse has been an important factor in the increase of the sale of charts, which has been fifty-seven per cent.; and through the same influence, acting in various ways, the general issue of charts has increased one hundred and sixteen per cent. The agents, who are in most instances the agents also of the Coast and Geodetic Survey, report that for similar reasons the sale of the Coast and Geodetic Survey publications has increased materially.

The collection of data for the study of the meteorology of the ocean has been facilitated in a remarkable degree. Many journals that have long been lost sight of, as the masters frequently transfer them without notifying the office, have been traced and recovered, and valuable data which has been withheld for a variety of reasons has been secured. The officers, by explaining the practical value of observations and the common benefit that will ensue, have induced many that were indifferent to contribute to this work. By careful comparisons or adjustment of instruments by means of the standards, with which all the offices are furnished, and a patient explanation of what is required, great interest has been aroused, and the distribution of blank meteorological journals to voluntary observers has increased one hundred per cent., while the increase in the accuracy of the observations cannot be estimated.

The services of the officers have been called into use to determine all kinds of questions of a nautical nature by all branches of the community, and the presence of professional men, always ready to investigate any subject, has been of great value to marine insurance companies, shipping agents, admiralty lawyers, and in fact to every branch of business connected either directly or indirectly with maritime affairs.

The number of vessels boarded by the officers attached to the branch offices during the year was 4,256, barometers corrected or compared 2,062, abstracts of logs made 873, wrecks reported 1,171, ice reported by 242 vessels, and information given to 2,286 different individuals.

During the year a set of new meteorological charts of the North Atlantic has been issued, and has been very favorably received. These charts present the principal meteorological phenomena of the ocean in a graphic form for each month in the year. The method is so comprehensible that a mere inspection shows what meteorological conditions the mariner may expect in each 5 degree square of the ocean surface. The data for these charts have been deduced from over two million hours of observations, extending over a period of forty years. The compilation of a similar set for the South Atlantic has been commenced, and is well advanced.

Light lists, numbering six volumes and embracing the lighthouses of the world, were corrected to July 1, sent to the printer and mailed to the ships of war, and to the agents for sale by the 20th of the month. The changes in lights are so frequent and often so radical, the value of a very late edition will be fully appreciated by mariners.

For the publications of the Hydrographic Office, a system of showing true bearings in degrees has been adopted, instead of magnetic bearings in points as was previously the custom.

The field for collecting information has been extended by establishing exchanges with every office in the world engaged in hydrographic work, and the attention of every one who has any interest in the examination of charts or in the discussion of matters regarding hydrography or cartography is called to the fact that this office possesses a complete file of the charts issued by all nations, and is always at the service of the public for the determination of any questions relating to them.

The information gathered through the Branch Offices in regard to floating dangers has been the means of the destruction by torpedoes of five wrecks, dangerous to navigation, which have been blown up by vessels acting under orders from the Navy Department.

The primary work of the Hydrographic Office should be the publication of the results of original surveys by American officers. A few small steamers should be placed at the disposal of this office to enable it to do its share of the hydrographic service demanded by the shipping interests of the country. The only vessel engaged making surveys during the year was the Ranger, on the west coast of Mexico and Central America.

The work done there, which extended from the Gulf of Fonseca to San Juan del Sur, has fully justified the outlay, and it is hoped that she will be kept in service indefinitely as a surveying vessel.

It cannot be too emphatically stated that this government should take a share of the general hydrographic work of the world commensurate with its maritime interests and importance. Charts are issued continually which, from the nature of their origin, are known to be only indifferent approximations to what should be represented. Good hydrographic reconnaisances can be made in a short time at comparatively slight expense; and when the danger to life and property is considered, there seems to be no excuse why many parts of the earth visited by our merchant marine, or in the general track of trading vessels, should be left in their present doubtful condition as regards hydrography.

The recommendation of previous hydrographers with regard to a survey of the Caroline and Marshall groups in the Pacific should be immediately carried out. The consul of the United States at Hong Kong, under date of July 21, 1884, reports to the Department of State the "loss of the American ship Ranier on the Marshall Islands, *owing to defective charts*, and urges that a survey be made of the Marshall, Caroline, and Pellew Islands." This has been repeatedly advocated by the Hydrographic Office, and when the position of these islands is considered, lying as they do in the trade wind and westerly current belt of the North Pacific, the natural highway of vessels bound to Japan, China, the Philippines and the East Indies, the conviction as to what should be done becomes irresistible. In the North Pacific alone there are more that 3,000 reported dangers which do not exist or are incorrectly located. In many cases the same island has a half dozen different positions assigned to it by as many authorities, the maximum difference often amounting to fifty miles. This is a source of continual uncertainty to mariners in these waters which ought to be eliminated, now that the science of deep-sea sounding is so well developed. So little time is necessary to sound in great depths that an examination of any locality where a danger is supposed to exist could be very quickly made, and the contour of the bed of the ocean absolutely determined.

Every vessel of the Navy should be provided with an apparatus, and be required to sound wherever the charts show no depths at distances of at least twenty miles. The method of examination by posting a lookout aloft while a vessel is in the vicinity of a danger is no longer of sufficient value to be accepted as final. The Hawaiian government is carrying on a hydrographic survey, to extend to a depth of 100 fathoms. The government of the United States should continue the soundings to the other principal groups of the Pacific.

New surveys of the north coast of South America and the West Indies are most urgently required. Our commercial interests absolutely demand better charts of this general locality. A vessel should be sent to the Spanish Main this winter to collect data for the revision of the charts of that region, which are mostly based on old Spanish surveys dating back to 1794. The coast of South America eastward of Trinidad, and the outlying islands, should also be examined immediately, and a vessel should be sent there this winter to commence the work.

Watson's rock, lying in latitude 40° 17' N., longitude 53° 22' W., in the path of North Atlantic traders, has been reported so many times that its existence ought to be settled definitely. A ship provided with a deep sea apparatus should be sent next summer to sound out this locality, and to develop the submarine mountain ridge that probably exists between the Azores and the Flemish Cap, as indicated by Milne Bank and the numerous reported dangers lying between the two extremes.

Last winter the United States Fish Commission Steamer Albatross, with a party composed entirely of naval officers working under the direction of the Bureau of Navigation, showed how efficiently this could be done. This party, among many other things, determined the position of a ridge between Santa Cruz and Puerto Rico which was known to exist from the investigations made into the temperatures of the Caribbean Sea by Commander Bartlett during the years 1879 and 1880.

This work, so eminently within the province of the Navy, and performed with so much success by naval officers, should be continued, and a ship should be fitted out expressly to make investigations into ocean temperatures at all depths, and thus obtain the data necessary to determine the actual circulation of the ocean.

THE SOLAR CORONA.

THE new pathway of astronomical research opened up by Kirchhoff twenty-five years ago, by means of the spectroscope, pointing as it did to a sure and certain method of acquainting ourselves intimately and definitely with the nature and constitution of bodies which lay far beyond the confines of our planet, raised the study of our sun, the nearest star to us, to the dignity of a special branch of scientific research. Many solar phenomena, the explanation of which had hitherto been little more than within the ken of vague conjecture, were before long satisfactorily cleared up, and others, of a still more intricate nature gave promise of yielding in time to a more searching inquiry. Among the latter may be mentioned one that, up to the present time, has remained an enigma, but which, so recent researches seem to indicate, cannot remain much longer unsolved—the nature of the solar corona.

The main difficulty in the way of the solution of this problem lay in the fact that the corona is only visible during total eclipses of the sun, and not only do these occur at comparatively infrequent intervals, but their duration is very brief, and they are only visible over a limited portion of the earth's surface. Six or seven minutes is an exceptionally long time for totality to last, and even to avail themselves of a much shorter time astronomers are often called upon to visit parts of the world quite out of the highways of commerce. Hence it is that places previously almost unheard of find themselves suddenly blazing forth into fame and notoriety, and are subsequently given a place in history, solely from the fact that on such and such a day instruments were there erected and pointed at a brief but glorious celestial spectacle.

In observations of such phenomena, the first half of the present century saw but little advance beyond what had probably been noted ages before methodical scientific inquiry turned its attention to the subject. For some little distance round the dark shadow of the moon a brilliant halo or crown was seen, of a silvery whiteness, with rays or streamers extending from it at irregular intervals; yet closer to the dark shadow were seen, on some occasions, brilliant red projections of light, but very small indeed in extent compared with the white halo. These last, the red prominences, yielded up their secret sixteen years ago, when the ingenuity of Messrs. Janssen and Lockyer demonstrated how they might be examined by means of the spectroscope without the aid of an eclipse at all.

The silvery halo or corona has proved a far more intricate puzzle. Sketches were made of it from time to time, but beyond establishing the fact that it varied from eclipse to eclipse, these sketches elicited nothing. Nay, so late as 1878, when a train of observers stretching across a considerable portion of the American continent came to compare results, it was found that their sketches at most only half agreed even when they were taken in the same locality. True, they indicated the most remarkable features of the corona, yet they rendered plainly evident what had long been suspected, that the eye was not sufficiently trustworthy to note, nor the hand, therefore, to record, the appearance of so fleeting a phenomenon, and all sketches of the corona during earlier eclipses can only be regarded as vague and unsatisfactory records. Previous to the American eclipse, however, astronomy had found an invaluable ally in photography. By means of this ally one very important fact had been established in 1871 in the work of Messrs. Henessy, Waterhouse, and Davies—that at two places, very far apart, the features of the corona appeared identical. This at once excluded local and terrestrial conditions or causes.

As to the nature of the light of the corona, two instruments have been consulted, the polariscope and the spectroscope. The first showed that part of the light of the corona is due to reflected light. The spectroscope has had a more difficult task to accomplish. This instrument could only examine effectively a small portion of the corona light, just so much as would pass through a fine slit. When the prisms spread this fine beam of light out into a band, its effect upon the retina was very feeble, and the eye could grasp only the most marked features. The spectrum appeared mainly continuous. Here and there a few of the strongest of the dark solar lines were seen by some observers, re-enforcing the work of the polariscope in showing that the corona derives part of its light from the main body of the sun. In addition, certain bright lines have been seen; one notable line in the green portion of the spectrum has been observed during most eclipses extending for some distance from the sun's limb. The exact position of this line in the spectrum was determined, and the same line can be seen as a dark line in the ordinary solar spectrum, but what substance it is due to has yet to be discovered, and remains an important problem for the chemist to determine in the laboratory.

The light from the corona, after passing through the spectroscope, being too feeble to permit an observer to examine it very minutely during the short space at his disposal, it became necessary to see whether the photographic method might be applied. An attempt was made to do so in 1875 during the Siam eclipse, but accidents on the road having delayed the scientific party, the preparations were

not perfect when the eventful moment arrived. Nothing further could be done till 1882, but by that time considerable improvements had been effected in the methods. Photography, commercial and scientific, had undergone a complete revolution. The old wet-collodion process, which had for so long a period held sway, was superseded, and the gelatine dry plate method, which had gained for itself the popular but unsatisfactory title of "the instantaneous process," had taken its place. The power of the astronomical photographer had been multiplied twenty to forty fold, and as all concerned had anticipated, one difficulty attending the spectroscopic examination of the coronal light disappeared. The accumulated effect of the light during an exposure of 65 seconds produced a result which could be critically examined at leisure, and it was found that in addition to a faint indication of reflected solar light the corona emitted a definite light of its own; a number of bright lines which could be identified with those given out by known substances were seen, and it could no longer be doubted that a large extent of the corona was due to matter connected more or less intimately with the sun. A further photograph of the coronal spectrum was taken by Messrs. Lawrance and Woods on Caroline Island last year, but the full report of this expedition has not yet been published. From what has already appeared we need only state that the bright lines were not so marked as in the photograph taken during the preceding eclipse, a noteworthy fact when considered in relation to the feeble activity of the sun at that time.

One of the most remarkable features of the photograph of the coronal spectrum was the intensity of the light in blue rays, and this led Dr. Huggins in England to try whether the corona could not be photographed without the aid of an eclipse at all. If this blue light could be isolated by using some colored medium that would cut off the other rays, might not the light of the corona be found to sufficiently exceed in intensity the glare of the light diffused by the atmosphere, as to be capable of impressing itself on a sensitive surface? Before this could be attempted, however, there was a physical difficulty to be overcome. The intensity of the solar light is so great that before the corona could be impressed, light scattered by that part of the film on which the sun's image fell would have reached the back of the plate and have been reflected back to the sensitive film, obscuring the effect of the coronal light or, worse still, producing a result somewhat resembling it. This was got over in a way familiar to photographers by placing a thick layer of asphaltum in optical contact with the back of the plate; by this means all "halation," as it is termed, was effectually stopped. It was afterward suggested that the sun's image should be blocked out by means of a blackened disk; the chief drawback to this, though, as will be seen in the sequel, one that can readily be avoided, is the danger of introducing diffraction. For the absorptive medium, Dr. Huggins tried blue glass and also a solution of permanganate of potash, and, after some time, succeeded in getting what competent judges regarded as the corona.

But there are several objections to the use of an absorptive medium, the most serious one being the difficulty of determining how much of the result might be due to the various reflecting surfaces introduced. Considering, moreover, that photographic films are themselves so selective, being very much more sensitive to blue rays than to any other part of the spectrum, it was not thought impossible that the blue glass or the permanganate of potash might be dispensed with, and the question arose whether, by suitable manipulation in the development of the image, the corona might not be brought up to a greater extent than the light of the sky, which tended to overpower it. Photography has achieved the reputation of having a strict regard to truth, and in a sense this reputation has been well earned; nevertheless, it is a fact that has been well known ever since photography took a hold upon the public, that no small amount of its success has been due to the power which photographers possess of subduing or heightening contrasts of light and shade at will, simply by properly regulating the exposure and altering the proportions of the chemicals used in rendering visible the invisible alteration which light has made. It is not to be wondered at, therefore, that such a method of working should have been successfully applied to the photographing of the corona, provided that the atmosphere was clear enough to permit the corona to outshine the atmospheric glare or light of the sky to a sufficient extent to enable the heightening of contrast to be effective. And in this proviso lay the chief difficulty, such occasions being comparatively rare in England, only a few days in the year being available for the purpose. In 1883, when Dr. Huggins hoped to be able to compare results taken by his method with what the eclipse observers might bring home from the mid Pacific, he could only get a photograph a month previous to the day of the eclipse, and another photograph a month after that event. When comparisons were made, the results were enough, however, to demonstrate that steps should be taken to see whether the process was really workable in a suitable locality, and, if so, what might be learnt from an extended series of observations.

The diminution of atmospheric glare being the principal consideration, Switzerland offered itself as the most suitable place, being within easy distance, and offering a clear atmosphere with facilities for reaching a great height with less inconvenience than is to be met with elsewhere. Accordingly, during the season now about to close, visitors to the Riffelberg have been astonished to see on a little elevation at the back of the hotel, at a height of 8,500 feet, a green tent about 12 or 13 feet long and nearly as high, formed of waterproof canvas stretched over a strong framework attached to the solid rock by iron pegs. On fine days they have noticed that the upper two-thirds of the southern side of this tent has been completely drawn up, allowing a long and somewhat cumbrous looking instrument to be pointed to the sun and to follow it in its course across the heavens. That it could not be an ordinary telescope every one could see, and it required a glance at the formidable array of bottles and the small cardboard chamber at one side to tell the visitor that the object sought after was connected with solar photography. This is the temporary observatory for the corona erected at the expense of the Royal Society and in charge of Mr. C. Ray Woods, a member of the last two eclipse expeditions.

For work of this character the present year has been rather an unfortunate one. The reader will remember that in August last year a tremendous eruption took place in the Sunda Straits, and was followed by singular meteorological phenomena; at sunrise and at sunset in all parts of the habitable globe, afterglows of singular beauty were observed. When the sun was a little below the horizon the sky appeared to be of a bright red hue, and by force of contrast, light clouds, the moon, and even the very lamps in the street appeared tinged with green.

It was put forth, though somewhat diffidently at first, that these afterglows were due to the volcanic eruption; that particles of finely divided matter were hurled up into the higher regions of the atmosphere, were wafted over the earth, and remaining suspended in the higher regions where clouds could not speedily attract them, and rain wash them down, gave rise to the gorgeous display of color that was remarked in places as far apart from themselves and the center of disturbance as England and Honolulu. Evidence accumulated in support of this theory, and unless some better explanation can be advanced, acceptance of it can hardly be avoided. From the fact that these sunrises and sunsets lasted for such a length of time, and have extended into the present year, but with diminished glory, it was conjectured that the particles which gave rise to them would probably take years to settle. Not only have these red glows been met with in Switzerland this summer, but another phenomenon has forced itself upon the attention of tourists. On all clear days a peculiar red ring has been observed extending round the sun at a distance of about 20 degrees. Outside this ring the sky has appeared blue, and between the ring and the sun nearly white. The higher the elevation the more marked has this ring appeared, but at any given place it has been most noticeable when the sun has been below the horizon. This peculiar haze has rendered corona photography more difficult than was anticipated, but even taking this light-scattering medium into account, a Swiss sky at a high altitude is far superior to the clearest atmosphere we get at home. It may be said that in the same ratio that the Swiss air has been clearer than the English atmosphere that Dr. Huggins has to overcome, so are the photographs obtained in Switzerland during the last six or eight weeks superior to the few that had been obtained in England.

The interposition of a circular disk between the sun's image and the photographic plate has been tried with success, and, by using a disk a little larger than the sun's image, all danger of diffraction or light turning the corner is done away with; and though the results are necessarily far inferior to the photographs obtained during eclipses when the disk, if it may be called such, is the dark body of the moon, they possess this advantage—they constitute to all intents and purposes a continuous record for a brief period. What these photographs may yield on a critical examination remains to be seen. One step has certainly been gained. Dr. Huggins' method appears capable of giving under suitable conditions a daily record of the form at least of the corona, and after a little more experience in the work further improvements may bring about something more.

Whether an extended series of photographs of the solar corona will lead to a complete explanation of its nature is doubtful. A further discovery may yet have to be made, viz., how to examine the spectrum of the corona without an eclipse. Did the corona spectrum consist of merely a few bright lines, as is the case with the red prominences, the question would have been settled long ago. It is of a far more complicated nature, however, and no solution of the matter appears imminent. It is more than probable that could observations be made at heights where life could with difficulty be sustained, there would be still enough atmospheric glare to prevent the coronal spectrum being seen. On the whole, the best and most useful supplement to a daily series of coronal photographs is likely to be a series of photographs of the spectrum of different parts of the corona taken during some future eclipse of the sun.—*London Times.*

THE FUNCTIONS OF THE CEREBRUM.

THE question is debated among physiologists whether or not the gray cortical substance of the cerebrum presents distinct localization of functions, so that the senses of sight and hearing and the action of various groups of voluntary muscles may be referred to strictly limited portions of this stratum. The affirmative view is chiefly advocated by Professor Munk.

On the other hand, Professor H. Goltz, of the University of Strassburg, is led by his observations and experiments to deny every special limitation of the centers of certain groups of functions.

In order to prove that small, limited portions of the cortical substance are not the centers of given activities, muscular and sensitive, Goltz removed portions of the anterior portion of the brain, or of the occipital lobe, in certain dogs, sometimes on one side only and in other cases on both. He then studied the phenomena evinced by the animals months afterward. In judging of the results he is guided merely by the minimum of the disturbances which occur after the operations in question, and regards all manifestations which appear in some of the subjects but not in others as mere collateral disturbances which throw no light on the functions of the parts removed. The operations, it must be remembered, affected not merely the cortical layer, but to some extent, the white matter.

We extract from Pfluger's "Archiv fur Physiologie" a summary of the chief results.

We have to distinguish animals which had undergone an extensive bilateral removal of the anterior lobe (*a*) from those (*b*) in which a considerable part of the occipital lobe had extirpated. The following differences appeared:

1. A dog (*a*) retains sensation in all parts of his body. It is even demonstrable that, under certain circumstances, his sense of feeling is delicate. But he touches awkwardly, and treads (or attempts to tread) in vacant space. No muscle of his body is lamed or paralyzed. He can move all his muscles at will, but his movements are clumsy and helpless. He is especially awkward in taking food. He does not understand how to hold fast a bone with his fore paws. He does not hesitate to leap from a height, but the movement is awkward.

An intensification of reflex excitability is regularly manifested.

There is very often a change in his moral character; he becomes more irritable and quarrelsome. He gives, invariably, proofs of a general excitement. He is impatient, distracted, and runs restlessly about.

The sense perceptions are not much enfeebled.

The intelligence is always moderately reduced.

2. A dog of the class *b* has his sense of touch undisturbed, and feels well. He does not step on vacancy.

He cannot only use all the muscles of his body at pleasure, but these movements take place approximately with the same dexterity as in a dog in his normal condition. He displays no awkwardness in eating, and knows how to hold bones fast with his paws. He hesitates at leaping down even from a trifling height.

His reflex irritability is not increased.

If previously violent, he becomes good natured after removal of the occipital lobes. He is free from excitement, and both in his bearing and movements he appears quiet, discreet, and tranquil.

He suffers from a general and well-marked weakness of perception.

His intelligence is profoundly reduced.

Professor Goltz further adds that dogs of the class *a* become and remain meager, while those of the class *b* invariably grow fat.

According to these results, there cannot, as a critic in the *Naturforscher* observes, remain the slightest doubt that a dog which has lost the posterior lobes differs in very essential points from one which has undergone a corresponding operation in the anterior portion of the brain. Hence, even in the opinion of Professor Goltz, the lobes of the cerebrum have not one and the same signification. It remains, however, an open question in how far the pathological phenomena above described are dependent on the extirpation of the gray substance or on the accompanying injury to the white matter.

The question cannot be decided experimentally, since it is not possible entirely to remove the gray matter without interfering with the white substance. Even if the latter is not mechanically injured, its nutrition is so compromised by the removal of the cortical layer that we cannot possibly suppose its normal action to be unimpaired. All experiments which aim at determining the functions of the gray substance are open to this source of error.—*Journal of Science.*

DETECTION OF GLYCERIN AND LIGNINE.

By C. REICHL.

THE author utilizes the colors which these substances give when treated with pyrogallic acid and stannic chloride. If a little of the substance supposed to contain glycerin is boiled with a little pyrogallic acid, a few drops of sulphuric acid, previously diluted with an equal volume of water, if the smallest quantity of glycerin is present, there appears a distinct red coloration, which turns to a fine violet-red on the addition of a solution of stannic chloride. Carbohydrates and certain alcohols must not be present, as they produce similar colorations. Lignine takes a fine violet color if boiled with pyrogallic acid and stannic chloride. Pure cellulose remains colorless.

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TABLE OF CONTENTS.